PREPARED FOR THE
DEPARTMENT OF THE ARMY
Contract DAHC19-69-C-0017

RAC-TP-445
FINAL DRAFT
OF VOL II

JANUARY 1972

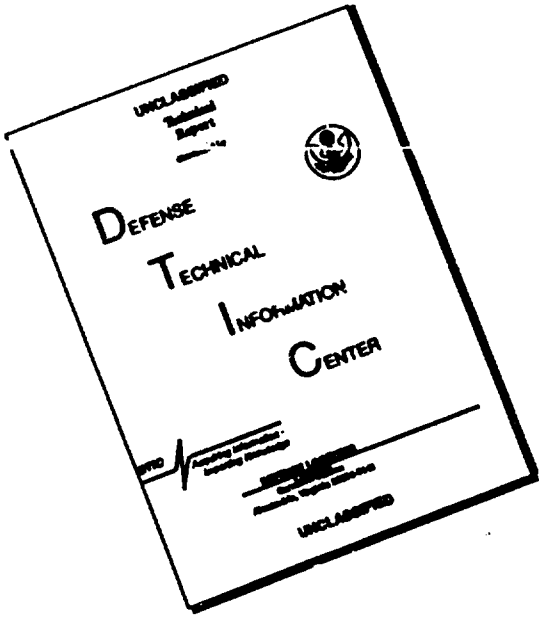
A Methodology for Optimal Planning over Time

Volume II
Appendices A, B, C, D, and E in Support of Volume I

by Charles A. Allen
Beverly D. Causey
James E. Falk
Ronald G. Magee
Charles W. Mylander
Ronald New, *Project Director*
John D. Pearson
Philip D. Robers

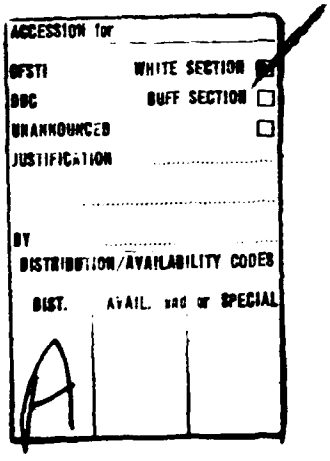
RAC Research Analysis Corporation

DISCLAIMER NOTICE



THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.



UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) RESEARCH ANALYSIS CORPORATION	2a. REPORT SECURITY CLASSIFICATION none
	2b GROUP N/A

3. REPORT TITLE

A Methodology for Optimal Planning Over Time, Volume II, Appendices A,B,C,D,&E

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Technical Paper

5. AUTHOR(S) (First name, middle initial, last name)

Charles A. Allen, Beverly D. Causey, James E. Falk, Ronald G. Magee, Ronald New, Project Director, John D. Pearson, Philip D. Robers, Charles W. Mylander

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
January 1972	284	2

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 011.310	TP-445, Final Draft of Vol II
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

10. DISTRIBUTION STATEMENT

Approved for public release;
distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	US Army, Combat Developments Command Combat Systems Group

13. ABSTRACT

This report describes a methodology which can be used to identify the most cost-effective plan for the phase-in and phase-out of vehicle systems -- a methodology for optimal fleet planning over time. Volume I provides a systematic development of the problem structure, a qualitative description of the solution procedure, and mathematical and operational descriptions of the algorithm. Volume II provides appendices containing a demonstration problem, subroutine descriptions, program flow charts, program listings, and error message descriptions.

DD FORM 1 NOV 68 1473

UNCLASSIFIED

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
branch and bound						
fleet planning						
non-convex programming						
non-linear programming						
optimization over time						
vehicle systems						

SCIENCE AND TECHNOLOGY DEPARTMENT RAC-TP-445 FINAL DRAFT OF VOL II Published January 1972

A Methodology for Optimal Planning over Time

Volume II

Appendices A, B, C, D, and E in Support of Volume I

by

Charles A. Allen
Beverly D. Causey
James E. Falk
Ronald G. Magee
Charles W. Mylander
Ronald New, *Project Director*
John D. Pearson
Philip D. Robers

FINAL DRAFT

Research Analysis Corporation

RAC

McLean, Virginia 22101

Area Code 703
893-5900

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF RESEARCH AND DEVELOPMENT
WASHINGTON, D.C. 20310

DARD-ARS

1. Volume I, "A Methodology for Optimal Planning Over Time" and Volume II, "Appendices A, B, C, D and E in Support of a Methodology for Optimal Planning Over Time - Volume I," were prepared by the Research Analysis Corporation for the Combat Systems Group, United States Army Combat Developments Command, and document RAC study 011.310, "Aircraft Systems Least Cost Phase-In." Copies of these reports are forwarded for your retention and use.

2. The methodology described in these volumes was developed to meet in part the need of the US Army to determine an optimal plan for phasing in new aircraft systems to meet its worldwide commitments yet remain within budgetary constraints. It provides to planners a tool for use in planning situations involving consideration of large numbers of alternative systems and combinations of tasks.

3. The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

FOR THE CHIEF OF RESEARCH AND DEVELOPMENT:

STANLEY R. MEEKEN
Colonel, GS
Chief, Studies and Analyses Division

Published January 1972
by
RESEARCH ANALYSIS CORPORATION
McLean, Virginia 22101

CONTENTS

VOLUME I

FIGURES: VOLUME I

FIGURES: VOLUME I (continued)

CONTENTS
VOLUME II

FIGURES: VOLUME II

APPENDIX A

A SAMPLE PROBLEM

We have chosen a relatively small sample problem to illustrate an implementation of the branch-and-bound algorithm and its corresponding program. We will structure the problem from a user's viewpoint, formulate the objective function and the constraint set, illustrate the preparation of the data decks and user's subroutines, and explain the logic of the results. The problem to be described here has been discussed in a previous document.[4]

The Ace Trucking Co., in planning for next year's workload, estimates that the company can serve its customers with a fleet of 67 light trucks and 16 cross-country trailers. An alternative fleet was also considered consisting of 43 light and 20 medium sized trucks, together with only 7 cross-country trailers. Finally, the only other practical alternative considered was a mix of 42 medium trucks and 12 of the big trailers. The medium trucks, however, are of a new design and will not be available for next year unless the company is willing to pay a substantial premium. At first it appeared that choosing one of these three alternative fleets (shown in table form below) was

	light trucks	medium trucks	trailers
Alternative #1	67	—	16
Alternative #2	43	20	7
Alternative #3	—	42	12

Figure A-1 ALTERNATIVE FLEET MIXES FOR 1972

the only decision issue. However, it soon became clear to the planning group at Ace Trucking Co. that the investment decision should also depend on the utilization of the trucks in subsequent years, in addition to that utilization planned for the next year. And furthermore, the existing fleet of trucks was far from obsolete, even though maintenance costs on some of the older vehicles were beginning to climb. Realizing these factors, the planning group estimated the workload for their trucks over the next three years (beyond which they could not be confident of their estimates), and then prepared a requirements table like that in Figure A-2 below.

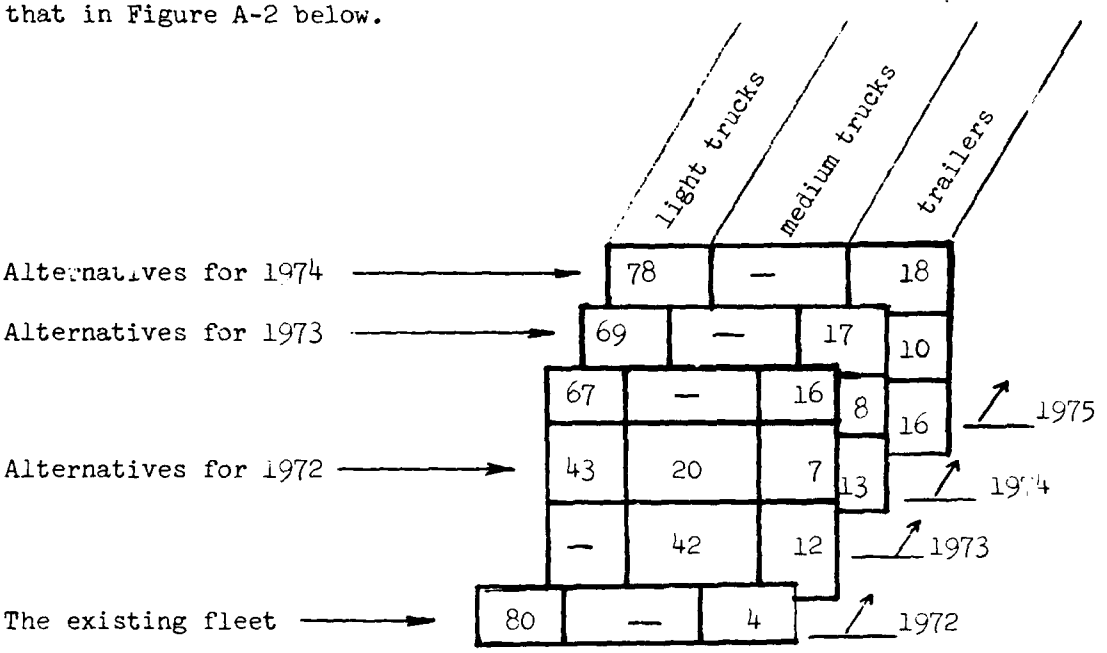


Figure A-2 CAPITAL EQUIPMENT (TRUCK) REQUIREMENTS AS A FUNCTION OF TIME

The existing fleet did not include any medium sized trucks; 60 light trucks were two years old, but the remaining 20 were purchased only last year. The inherited trailers were also two years old. Finally, based on the projected cash flow position of Ace for the next three years, it was decided that a limit (cost constraint) be placed on new truck procurements for each of the three years.* Decision time for Ace

* Costs constraints were not imposed on this problem in the previous referenced description;[6] hence, a slightly different solution was obtained.

Trucking Co. is January 1/72, and the question is: what is the optimal plan over the next three-year period?

Initially, one should ask: how many alternative plans exist? If we permute three alternatives per year with three years, we develop 27 alternative plans — but this number ignores all permutations of the existing fleet as well as all concern for the "welfare" of the inherited fleet from year to year. In addition, there are questions like "buy" or "lease," ... "sell," "salvage," or "store," etc., making the number of alternative plans very large indeed (literally thousands even in this trivial problem). In fact, for real-world problems, it would not be atypical to have millions of possible alternative plans confronting the decision-maker, each involving a maze of cost factors — making evaluation of each and every plan rather impractical. Problems like this can be solved efficiently, without evaluating each and every alternative, using the mathematical programming techniques embodied within the Faik-Klingman Algorithm.[2]

The objective function for this problem is developed from the general form of Fig. 2-1 (page 2-11) plus projected estimates of the cost coefficients for each cost category. We have only three vehicles under consideration but we artificially introduce a fourth vehicle (and call it MEDIUM*) to account for the premium charge if we buy MEDIUM trucks for the first year (1/72). That is, the program will treat the purchase of MEDIUM trucks and MEDIUM* trucks separately, as if they were distinct. In figure A-3 we show the reduced form of the objective function. Note that,

(1) There is only one (possible) R&D charge and that is associated with the MEDIUM* vehicles (called vehicle No. 1; the LIGHT, MEDIUM, and TRACTORS are numbered 2, 3, and 4, respectively.

(2) We use a increase in operating cost over time (for simplicity), hence, we drop the second subscript in the c coefficients as well as the summation over k.

(3) We have introduced the specific values for the number of vehicles (N=4) and the length of the planning period (T=3) where they appear in Figure A-3.

$$\varphi(x) = U_1(x_1) + \sum_{J=1}^{4} a_J x_J^{b_J} + \sum_{J=1}^{4}\sum_{\ell=1}^{3}(-d_{J\ell})s_{J\ell}$$

R&D Costs — Procurement Costs — Savings due to mothballing of unneeded vehicles

$$+ \sum_{J=1}^{4}\sum_{\ell=K_J}^{0}\sum_{m=1}^{3} c_J w_{J\ell m} + \sum_{J=1}^{4}\sum_{\ell=1}^{3}\sum_{m=\ell}^{3} c_J x_{J\ell m}$$

Operating and maintenance cost

(inherited fleet) (purchased fleet)

$$+ \sum_{J=1}^{4}\sum_{\ell=K_J}^{0}\sum_{m=0}^{2}(-e_{J,(m-\ell+1)})w_{J\ell m} + \sum_{J=1}^{4}\sum_{\ell=1}^{3}\sum_{m=\ell}^{3}(-e_{J,(m-\ell+1)})x_{J\ell m}$$

Savings resulting from vehicle salvage

(inherited fleet) (purchased fleet)

$$+ \sum_{J=1}^{4}\sum_{\ell=K_J}^{0}(-f_{J,(4-\ell)})w_{J\ell 3} + \sum_{J=1}^{4}\sum_{\ell=1}^{3}(-f_{J,(4-\ell)})x_{J\ell 3}$$

Savings due to crediting the value of fleet owned at the end of the planning period

(inherited fleet) (purchased fleet)

Fig A3 - The Simplified Objective (cost) Function For the Sample Truck Problem

The constraint set is developed from the general descriptions given in Chapter 3 (starting on p. 3-1).
The material balance constraints become:

$$\sum_{\ell'=K_j}^{0} \sum_{m=\ell}^{3} w_{j\ell'm} + \sum_{\ell'=1}^{\ell} \sum_{m=\ell}^{3} x_{j\ell'm} = \sum_{i \in M_\ell} \sum_{k=1}^{R_{i\ell}} u_{ijk\ell} p_{ik\ell} + s_{j\ell}$$

$$j = 1, 2, 3, 4$$
$$\ell = 1, 2, 3$$

Note that we have assumed no attrition ($v_{\ell-\ell'} = 1$), and have assigned the $t_{i\ell}$ factor = 1 for all mission groups.
The consistency constraints reduce to:

$$\sum_{k=1}^{R_{i\ell}} p_{ik\ell} = 1; \quad \ell = 1, 2, 3 \text{ and } i = 1, 2, 3$$

The vintage constraints for the light trucks and trailers are:

$$W_{j\ell} = \sum_{m=0}^{9+\ell} w_{j\ell m}; \quad j = 2, 4 \text{ and } \ell = -1, 0$$

where L_j has been replaced by 10 subperiods (years) for all vehicles and K_j by -1 for both inherited vehicles.
The master variable constraints are simply:

$$x_j = \sum_{\ell=1}^{3} \sum_{m=\ell}^{3} x_{j\ell m}; \quad j = 1, 2, 3, 4$$

Finally, since we have chosen to introduce cost constraints, we have

$$H_{\ell} = \sum_{j=1}^{4} a_j^o \sum_{m=\ell}^{3} x_{j\ell m} + P_{\ell} - P_{\ell-1}$$

We (i.e., Ace Trucking Co.) will set the cost constraint, H_{ℓ} = \$150,000., \$250,000., and \$300,000., for the three years of the planning period, respectively. The linear approximation a_j^o, to the procurement cost function will be selected after inspection of the actual cost vs. quantity curve.

A careful inspection of the total constraint set for this problem will indicate a total of 24 constraints (recall that there is no materiel balance constraint for [ℓ=1, j=3] and no vintage constraint for [j=4, ℓ=0]). Similiarly, a count of the number of variables (being careful to delete those which must equal zero because of specific exclusions in this sample problem) will indicate a total of 60. The reader will note that the GENLCP Program automatically computes and prints these totals for use in the BBCAV 2 Program.

We are now ready to prepare the data decks and user subroutines. The user subroutine GETPHI is shown in the program listing on page D-32. It is here that we describe the R&D and procurement equations for the four vehicles in the sample problem. Note that vehicle No. 1 (MEDIUM*) has an R&D (premium) charge of \$300,000.* — the other three vehicles have no R&D charge and their procurement costs are simply described by concave functions of the form ax^b. Of course, other forms of concave functions could have been used.

---

* We have chosen to scale all costs by 10^6. This means that all final cost data should be multiplied by 10^6.

The only other user subroutine YRCOST (see page D-19) is prepared for use in the GENLCP program, then duplicated for use in REPGEN. As described previously on p. 4-10 of chapter 4, YRCOST is used to calculate the operating, mothballing, salvage, and truncation cost coefficients, c_{jk}, $d_{j\ell}$, e_j, $(m-\ell+1)$ and f_j, $(Y-\ell+1)$ respectively. For our sample problem, we use no increase in operating cost overtime (R=0.); a mothballing savings factor of R1 = 0.9; a salvage savings factor of alpha = 0.5; and truncation savings based upon a linear decay from an estimate of the purchase cost (input through the GENLCP data deck) and an assumed 10 year lifetime for each vehicle.

The data deck for the GENLCP program can now be prepared (see figure A-4).

In entry (card image) No. 1 we give the problem title, the first and last year of the planning period, and then specify the four vehicle tables, three task tables, and five period tables — the first two of which are inherited periods. Entry 2 is the VEHICLE header card for the first vehicle. Entry 3 describes the first vehicle as LIGHT, indicates an availability date of 1970 (i.e. an inherited vehicle) and finally a ten year vehicle lifetime. Entry 4 indicates that 60 light vehicles were purchased in 1970 and 20 light vehicles were purchased in 1971. Entry 5 indicates a $3,000. purchase cost estimate for purposes of calculation of the truncation and salvage value, a ten year operating cost of $120,000., zero R&D cost for the light vehicle, zero attrition for the light vehicle, and finally an estimated linear purchase cost coefficient of $3,000., respectively. This linear purchase cost coefficient estimate was based upon a study of the corresponding non-linear procurement equation for the light vehicle. In general, one should choose the cost coefficient (slope of the straight line) such that the straight line intersects the non-linear curve at or about the estimated solution value. The consequences of a poor estimate will be described shortly. Entries 6 through 15 simply complete the vehicle tables. Entries 16 through 31 describe the period tables. The first two periods (1970 and 1971) are inherited periods. In period 1972 we indicate a cost constraint of $150,000. in entry 21. Entry 22 specifies that there exists only one task in 1972 and its scale factor is 1.0.

```
SAMPLE       1972 1974      4       3       5
VEHICLE
LIGHT      1970        10
          60         20
       .003        .12          0.0         1.0        .003
VEHICLE
MEDIUM*    1972        10
       .006        .14         .200         1.0        .006
VEHICLE
MEDIUM     1973        10
       .006        .14           0.         1.0        .006
VEHICLE
TRAILER    1970        10
           4
       .01         .16           0.         1.0        .012
PERIOD
1970 1970
PERIOD
1971 1971
PERIOD
1972 1972    .15
           1          1.0
    1   1.0
PERIOD
1973 1973    .25
           1          1.0
    2   1.0
PERIOD
1974 1974    .3
           1          1.0
    3   1.0
TASK
           1          2          3
LIGHT       MEDIUM*    TRAILER
67.0        0.0        16.0
43.0        20.0       7.0
0.0         42.0       12.0
TASK
           2          4          5
LIGHT       MEDIUM*    MEDIUM     TRAILER
68.0        0.0        0.0        17.0
45.0        22.0       0.0        8.0
0.0         45.0       0.0        13.0
45.0        0.0        22.0       8.0
0.0         0.0        45.0       13.0
TASK
           3          4          5
LIGHT       MEDIUM*    MEDIUM     TRAILER
78.0        0.0        0.0        15.0
48.0        24.0       0.0        10.0
0.0         50.0       0.0        16.0
46.0        0.0        24.0       10.0
0.00        0.0        50.0       16.0
ENDTABLE
```

Fig. A-4 The Sample Problem Data Deck for the GENLCP Program

The remaining entries in the period tables should be self explanatory. The task tables are input next. Entry 33 specifies that task No. 1 will have three vehicles and three alternatives. Entries 34 through 37 input the alternative set for the first year of the planning period (compare with the figure A-2). The alternative sets for the second and third years of the planning period follow. Note that because of the introduction of the artificial MEDIUM* vehicle, the complete set of permutations yield five distinct alternatives instead of the original three. This data deck ends with an ENDTABLE card in entry 54.

We now run (process) the GENLCP program and obtain the printout of Figure A-5; parts (a) through (f). Part (a) simply prints out some input information for checking purposes, and reorders the vehicles according to the magnitude of the R&D charge; note, in this regard, that the MEDIUM* truck is "called" vehicle No. 1 (X01) since it has the R&D charge.

In the first section of Part (b), a summary of the constraint equations for this sample problem is listed; the row type (E for equality and N for free), then the row name is printed in accordance with the symbolic naming convention of Fig. 4-3. The second section of part (b), and continuing in part (c), lists the variable, the columns in which it appears, and its corresponding coefficient. Similiarly, the last section, labeled RHS, gives a summary of those rows (constraint equations) which have non-zero right-hand-sides.

Part (d) provides a cross-reference list of variable number versus variable name for use in the interpretation of the output from the BBCAV2 program. The last section of part (d) indicates that there are 25 rows and 61 columns in this sample problem. Note that in each case these are one more than was indicated previously because the cost row and the right hand side variable, respectively are now included. Finally the upper bounds, computed by the GENLCP program, are listed for the master variables; the minus sign here is superfluous.

Part (e) prints a cost summary on each vehicle along with the components of the inherited fleet. Then in the last section of part (e) and continuing in part (f), the task (alternative) tables are reproduced.

```
 GENERATING THE MATRIX FOR THE LEAST COST PHASE-IN PROBLEM

FILENAME= SAMPLE   STARTING YEAR = 1972 LAST YEAR = 1974
WILL INPUT  4 VEHICLE TABLES, AND  3 TASK TABLE, AND  5 PERIOD TABLES.

 READING IN A VEHICLE TABLE
LIGHT           1970        10

 READING IN A VEHICLE TABLE
MEDIUM*         1972        10

 READING IN A VEHICLE TABLE
MEDIUM          1973        10

 READING IN A VEHICLE TABLE
TRAILER         1970        10

 READING IN A PERIOD TABLE
1970 1970

 READING IN A PERIOD TABLE
1971 1971

 READING IN A PERIOD TABLE
1972 1972

 READING IN A PERIOD TABLE
1973 1973

 READING IN A PERIOD TABLE
1974 1974

 READING IN A TASK TABLE
       1          3          3

 READING IN A TASK TABLE
       2          4          5

 READING IN A TASK TABLE
       3          4          5

   VEHICLE NAME     VARIABLE NAME
      OPTIONAL R+D VEHICLES
     MEDIUM*          X01
           OTHER VEHICLES
     LIGHT            X02
     MEDIUM           X03
     TRAILER          X04
```

Fig A-5(a) GENLCP Output For Sample Problem

```
NAME          SAMPLE
ROWS
 * E  SUMX01
 * E  SUMX02
 * E  SUMX03
 * E  SUMX04
 * E  PC01
 * E  PC02
 * E  PC03
 * E  IN02PM1
 * E  IN02P00
 * E  IN04PM1
 * E  X01P01
 * E  X02P01
 * E  X04P01
 * E  T01P01
 * E  X01P02
 * E  X02P02
 * E  X03P02
 * E  X04P02
 * E  T02P02
 * E  X01P03
 * E  X02P03
 * E  X03P03
 * E  X04P03
 * E  T03P03
 * N  COST
COLUMNS
 *          (PARTIAL LISTING)
 *     X01        SUMX01        -1.0000
 *     X02        SUMX02        -1.0000
 *     X03        SUMX03        -1.0000
 *     X04        SUMX04        -1.0000
 *     P01        PC01           1.0000
 *     P01        PC02          -1.0000
 *     P02        PC02           1.0000
 *     P02        PC03          -1.0000
 *     P03        PC03           1.0000
 *     X02M100    COST           -.0108
 *     X02M100    IN02PM1        1.0000
 *     X02M101    COST            .0116
 *     X02M101    IN02PM1        1.0000
 *     X02M101    X02P01        -1.0000
 *     X02M102    COST            .0238
 *     X02M102    IN02PM1        1.0000
 *     X02M102    X02P01        -1.0000
 *     X02M102    X02P02        -1.0000
 *     X02M103    COST            .0345
 *     X02M103    IN02PM1        1.0000
 *     X02M103    X02P01        -1.0000
 *     X02M103    X02P02        -1.0000
 *     X02M103    X02P03        -1.0000
 *     X04M100    COST           -.0015
 *     X04M100    IN04P00        1.0000
 *     X04M101    COST            .0112
 *     X04M101    IN04PM1        1.0000
 *     X04M101    X04P01        -1.0000
 *     X04M102    COST            .0225
 *     X04M102    IN04P00        1.0000
 *     X04M102    X04P01        -1.0000
 *     X04M102    X04P02        -1.0000
```

Fig A-5(b) GENLCP Output For Sample Problem

```
*     W020003   COST          .0342
*     W020003   IW02P00       1.0000
*     W020003   X02P01       -1.0000
*     W020003   X02P02       -1.0000
*     W020003   X02P03       -1.0000
*     W04M100   COST          -.0025
*     W04M100   IW04PM1       1.0000
*     W04M101   COST           .0147
*     W04M101   IW04PM1       1.0000
*     W04M101   X04P01       -1.0000
*     W04M102   COST           .0314
*     W04M102   IW04PM1       1.0000
*     W04M102   X04P01       -1.0000
*     W04M102   X04P02       -1.0000
*     W04M103   COST           .0430
*     W04M103   IW04PM1       1.0000
*     W04M103   X04P01       -1.0000
*     W04M103   X04P02       -1.0000
*     W04M103   X04P03       -1.0000
*     P030103   X02P03       78.0000
*     P030103   X04P03       18.0000
*     P030103   T03P03        1.0000
*     P030203   X01P03       24.0000
*     P030203   X02P03       48.0000
*     P030203   X04P03       10.0000
*     P030203   T03P03        1.0000
*     P030303   X01P03       50.0000
*     P030303   X04P03       16.0000
*     P030303   T03P03        1.0000
*     P030403   X02P03       48.0000
*     P030403   X03P03       24.0000
*     P030403   X04P03       10.0000
*     P030403   T03P03        1.0000
*     P030503   X03P03       50.0000
*     P030503   X04P03       16.0000
*     P030503   T03P03        1.0000
*     X010303   SUMX01        1.0000
*     X010303   X01P03       -1.0000
*     X010303   PC03           .0060
*     X010303   COST           .0085
*     X020303   SUMX02        1.0000
*     X020303   X02P03       -1.0000
*     X020303   PC03           .0030
*     X020303   COST           .0093
*     X030303   SUMX03        1.0000
*     X030303   X03P03       -1.0000
*     X030303   PC03           .0060
*     X030303   COST           .0086
*     X040303   SUMX04        1.0000
*     X040303   X04P03       -1.0000
*     X040303   PC03           .0120
*     X040303   COST           .0070
*RHS
*     RHS1      PC01           .1500
*     RHS1      PC02           .2500
*     RHS1      PC03           .3000
*     RHS1      IW02PM1      60.0000
*     RHS1      IW02P00      20.0000
*     RHS1      IW04PM1       4.0000
*     RHS1      T01P01        1.0000
*     RHS1      T02P02        1.0000
*     RHS1      T03P03        1.0000
*ENDATA
```

Fig A-5(c) GENLCP Output for Sample Problem

REFERENCE LIST FOR COLUMN NUMBERS AND NAMES

1	X01	2	X02	3	X03	4	X04	5	P01
6	P02	7	P03	8	W02M100	9	W02M101	10	W02M102
11	W02M103	12	W020000	13	W020001	14	W020002	15	W020003
16	W04M100	17	W04M101	18	W04M102	19	W04M103	20	P010101
21	P010201	22	P010301	23	X010101	24	X010102	25	X010103
26	S0101	27	X020101	28	X020102	29	X020103	30	S0201
31	X040101	32	X040102	33	X040103	34	S0401	35	P020102
36	P020202	37	P020302	38	P020402	39	P020502	40	X010202
41	X010203	42	S0102	43	X020202	44	X020203	45	S0202
46	X030202	47	X030203	48	S0302	49	X040202	50	X040203
51	S0402	52	P030103	53	P030203	54	P030303	55	P030403
56	P030503	57	X010303	58	X020303	59	X030303	60	X040303
61	RHS1								

IMPORTANT DATA ITEMS FOR INPUT TO BSCAVLP

NUMBER OF ROWS (INCLUDING COST) IS 25

NUMBER OF COLUMNS (INCLUDING RHS) IS 61

UPPER BOUNDS FOR VEHICLES IN ORDER FROM X1 THRU XN ARE

-137.0000

-214.0000

-95.0000

-51.0000

Fig A-5 i) GEILCP Output For Sample Problem

VEHICLE NAME	VARIABLE NAME	SAL/TRUNC COST	O AND M COST	R AND D COST	RETENTION RATE	YEAR FIRST AVAILABLE	LIFE IN YEARS
MEDIUM*	X01	.0060	.1400	.3000	1.0000	1972	10
LIGHT	X02	.0030	.1200	0.0000	1.0000	1970	10
MEDIUM	X03	.0060	.1400	0.0000	1.0000	1973	10
TRAILER	X04	.0100	.1600	0.0000	1.0000	1970	10

COMPONENTS OF THE INHERITED FLEET

	1970	1971
NUMBER OF X02	60	20
NUMBER OF X04	4	-0

TASKS REQUIRED IN PERIOD FROM 1972 THROUGH 1972

TASK 01 - PERFORMED BY 1.00 FORCE ELEMENT(S), WITH SCALE FACTOR EQUAL 1.000

* VARIABLE ********* ALTERNATIVE	X01	X02	X04	X
1	0	67	16	
2	20	43	7	
3	42	0	12	

Fig A-5(e) GENLCP Output For Sample Problem

The reader should note that very little near new information is produced by the GENLCP program — for the most part, GENLCP merely formats, reorders, checks, and performs bookkeeping operations in preparation for entry to the BBCAV2-REPGEN algorithm.

The first data deck for the BBCAV2-REPGEN algorithm is prepared as illustrated in figure A-6. We first assign a solution name in entry 1. The first, second, fourth and fifth fields of entry 2 are omitted as described on page 4-26. The third field in entry 2 indicates that there are four concave cost functions. The zero in the sixth field suppresses printing of the subroutine calls; the 1 in field No. 7 prints a listing of the primal iterations of each linear program; and the 1 in field No. 8 prints the entire set of LP solutions. Fields 9 and 10 are the standard specifications for the size of the array BLIST. The 1 in field No. 11 prints the column numbers and their corresponding values for each node. The last field, set to 20, establishes the limit on the number of nodes that will be evaluated prior to termination.

Entry 3 has four fields which establish (1) a tolerance factor of 0.005 (i.e., the solution will be within one-half of one percent of the theoretical optimum), (2) a program time limit of 90.0 seconds prior to termination (the solution to the sample problem actually used only 48 central processor seconds), (3) that no initial solution (basis) will be input, and (4) that we wish to obtain a detailed output. The second data deck for the BBCAV2-REPGEN algorithm is prepared as illustrated in figure A-8. As discussed on p. 4-35, the REPGEN data deck is very easy to prepare since most cards are duplicates of the GENLCP data deck. After the title card, the vehicle tables are inserted with cards of type 2 deleted. The period tables come next using only the header cards and cards of type 1. Note that the period designators have been inserted on all cards of type 1 in columns 11 and 12. The ENDTABLE card in entry 24 ends the data deck.

When the BBCAV2 program in the BBCAV2-REPGEN packet is loaded and processed, the printed output gives complete information vis-à-vis the optimal solution as well as all intermediate nodal solutions. The printout is long and involved and is in a coded format. The REPGEN program in the BBCAV2-REPGEN packet will decode the BBCAV2 output and

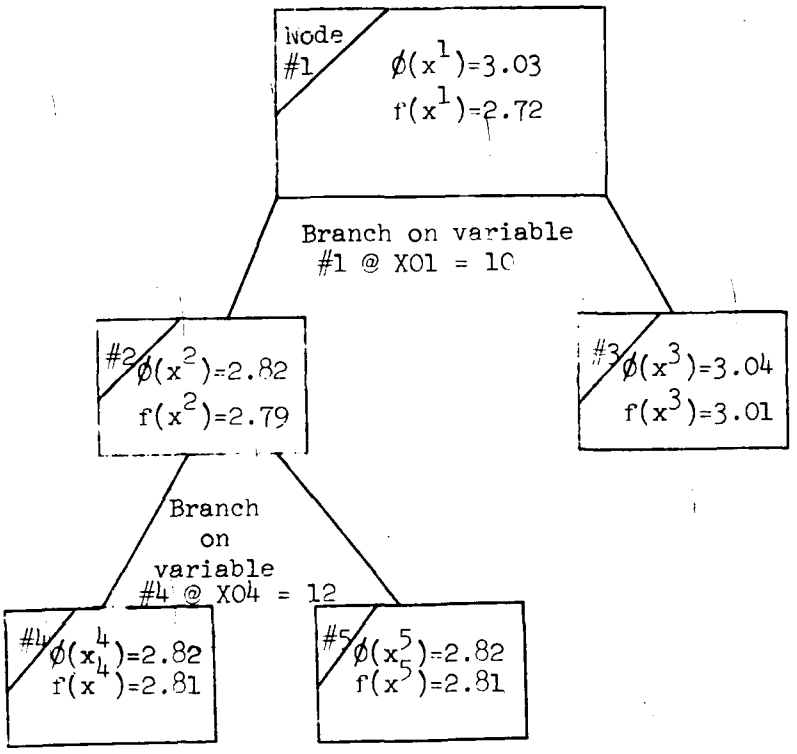
```
1 SAMPLE---SIMPLE TRUCK PROBLEM---OPTIMAL
2                    4                  0    1    1     25   131    1   20
3       0.005        90.0         0.0          1.0
```

Fig. A-6 The Sample Problem Data Deck For the BBCAV2 Program

present all essential information, hence, we neither present nor discuss the BBCAV2 output. After some experience with these programs, the user may suppress all intermediate information if he so desires. We do present here a branching tree (like that of Fig. 2-2b) to lend further clarity to the intermediate solution.

The "tree" of intermediate solutions (see Fig. A-7) is illustrative of the iteration process of the branch-and-bound algorithm. Node #1 represents a complete linearization of the non-linear problem and establishes the first reference solution, $\phi(x^1)$ = 3.03 million dollars. A lower bound to all solutions, $f(x^1)$, is also determined and equals 2.72 million dollars. The branching rule is then applied and variable #1 is selected, at the branching value of X01 = 10. The linear programs associated with node #'s 2 and 3 are then evaluated. Node #2 yields a better reference solution of $\phi(x^2)$ = 2.82. Node #3 is found to contain no better solution than $\phi(x^2)$ because $f(x^3) > \phi(x^2)$, hence node #3 need no longer be considered. The next best branching variable is #4, at a value of X04 = 12. The linear solutions to nodes 4 and 5 yield identical results, indicating a solution at the bound. The process terminates here because the smallest lower bound is within one-half of one percent of the current reference solution. Detailed information regarding the optimal (and final) solution is obtained through the REPGEN program.

REPGEN in the BBCAV2-REPGEN algorithm is then processed resulting in the output of figure A-9, parts (a) and (b). Part (a) contains an overall COST INFORMATION summary together with a breakdown of the number of PURCHASED RESOURCES (vehicles). Part (b) illustrates a breakdown of the STORED (mothballed) RESOURCES and the TOTAL RESOURCES USED by period. From these tabulated results, we have constructed a bar chart in figure A-10 to better illustrate the optimal solution. In this display, the results of a cost minimization over time are illustrated by a bar for each year and each vehicle. The height of the bar is a measure of how



$\phi(x^i)$ = the actual (non-linear) solution for node i.

$f(x^i)$ = the lower bound (linear) solution for node i.

Figure A-7 A Branching Tree for the Sample Problem

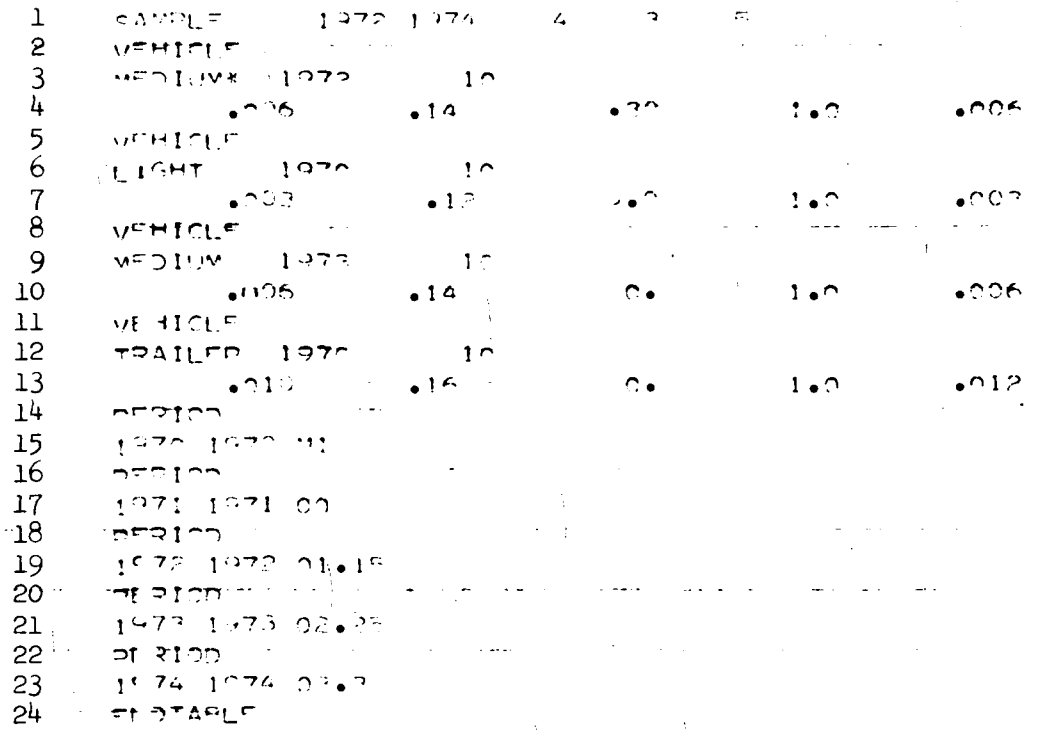


Figure A-8 The Sample Problem Data Deck For The REPGEN Program

many vehicles were selected – the color black indicates vehicles existing or retained – a dotted section indicates vehicles purchased – a blank section indicates vehicles stored (mothballed) for later use. One can observe the trend toward a fleet of only medium trucks and trailers (perhaps because of the high labor costs of operating so many light trucks). The MEDIUM* trucks are not chosen for 1972 because of the high purchase cost for early delivery. The slack is taken up by a large purchase of trailers in this first year; the trailers are needed in the later years anyway. Storage of a few trailers is indicated in 1973.

SAMPLE---SIMPLE TRUCK PROBLEM---OPTIMAL

COST INFORMATION

	R AND D	PROCUREMENT	OPERATING	SALVAGE	TOTAL
PERIOD 01		.112	1.060	.019	1.152
PERIOD 02		.199	.856	.026	1.029
PERIOD 03		.034	.956	.001	.989
TOTAL	0.000	.345	2.872	.047	3.170

TRUNCATION VALUE FOR RESOURCES = .348

SAMPLE---SIMPLE TRUCK PROBLEM---OPTIMAL

PURCHASED RESOURCES

	MEDIUM	LIGHT	MEDIUM	TRAILER
PERIOD 01	0.000	0.000	0.000	12.000
PERIOD 02	0.000	0.000	42.667	0.000
PERIOD 03	0.000	0.000	7.333	0.000
TOTAL	0.000	0.000	50.000	12.000

Fig. A - 9(a) REPGEN Output For Sample Problem

14113

SAMPLE---SIMPLE TRUCK PROBLEM---OPTIMAL

STORED RESOURCES

	MEDIUM*	LIGHT	MEDIUM	TRAILER
PERIOD 01	0.000	0.000	0.000	0.000
PERIOD 02	0.000	0.000	0.000	2.793
PERIOD 03	0.000	0.000	0.000	0.000

SAMPLE---SIMPLE TRUCK PROBLEM---OPTIMAL

TOTAL RESOURCES USED

	MEDIUM*	LIGHT	MEDIUM	TRAILER
PERIOD 01	0.000	67.000	0.000	16.000
PERIOD 02	0.000	3.578	42.667	13.207
PERIOD 03	0.000	0.000	50.000	16.000

Fig. A - 9(b) REPGEN Output For Sample Problem

(perhaps a surprising result but, under the circumstances, a reasonable one since buying medium trucks or retaining a larger number of small trucks for this sub-period are very costly alternatives). Finally, one can observe the relatively high start-up costs due to the purchase of the entire trailer fleet in 1972, and then most of the medium truck fleet in 1973. Nevertheless, these high start-up costs yield the least total cost over the planning period.

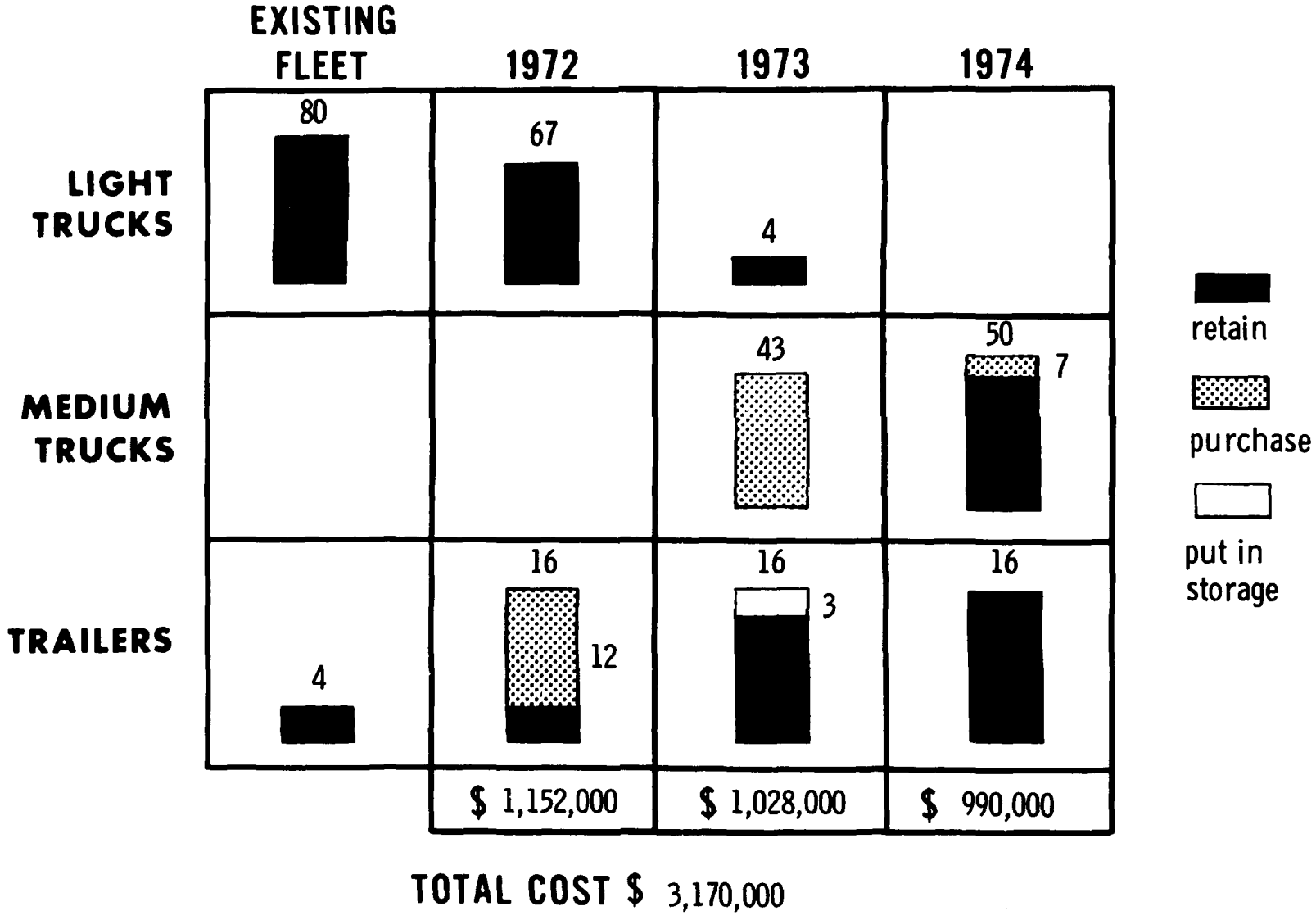
The COST INFORMATION summary indicates a total real cost (that which must be allocated) of 3.17 million dollars. This differs from the branch-and-bound solution value of 2.82 million dollars by the truncation value; i.e., it is deemed proper to include the truncation credit for purposes of optimization, but this dollar credit (unlike salvage) is not considered to be available for other purposes. From the procurement cost summary, it would appear that none of the procurement cost constraints were binding; however, the reader should recall from p. 4-36 that these data were calculated from the linear procurement estimates and, upon close inspection of the BBCAV2 printout, one could observe a binding cost constraint in the second period. As previously intimated on page A-7, this relatively poor correlation between linear estimate and actual value (in this case in the medium vehicles) can give erroneous results.* For cases in which the discrepancy is excessively large (judged not so in this sample problem) the programs should be reprocessed with a better linear estimate. The restriction of available funds in period two is <u>probably</u> the cause of the retention of the light vehicles, in lieu of the purchase of the full complement of medium vehicles for that period. Finally, one should observe that the RESOURCE summaries in general contain non-integer values — a consequence of the continuum of solutions to linear programming problems. It is incumbent upon the user to provide a physically meaningful interpretation to such results — as we have done for this sample problem in figure A-10.

---

* The difficulties introduced here due to a poor linear estimate can be avoided in the future by employing a recently developed modification to the current algorithm.[5]

Figure A-10

A Sample Optimal Plan for the Ace Trucking Company



TOTAL COST $ 3,170,000

APPENDIX B

SUBROUTINE DESCRIPTIONS

APPENDIX B

MATRIX GENERATOR ROUTINE DESCRIPTIONS

GENLCP - reads and analyzes input data, creates column names and row names, determines non-zero values of the matrix of coefficients, creates the MPS360 file, and outputs the documentation listing.

YRCOST (J) - has parameter J, which is vehicle number, and determines for this vehicle all cost information (see Chapter 4 for detailed description).

YINTERP (NVR, NTR, NRY) - determines for all tasks (NTR) which of the NVR vehicles will not have been developed by the year NYR, and eliminates from those tasks all alternatives in which the "non-existent" vehicles are accomplishing something which could be done by an existing vehicle.

MATFILL (N, M) - creates from the MPS360 file the file for BBCAV2 which is an N-row by M-column matrix of coefficients, and also creates the reference list for matching column numbers and names.

MAIN PROGRAM ROUTINE DESCRIPTIONS

BBCAV2 - is the programmed implementation of the main logic structure of the branch and bound algorithm; selects node from branching tree, branches on it defining two new nodes, and determines when optimality has been achieved.

BCX1 - defines the initial node of the branching tree and establishes the problem framework in which the main program will iterate.

INITA (NCF, N, M) - reads the matrix file from tape and stores it on disk in the form acceptable to the LP; the parameters N and M define the number of columns and rows in the matrix, and the parameter NCF is the number of columns having nonlinear cost functions.

GETPHI (KFX, XPHI, PHI, SUMPHI) - evaluates the nonlinear cost functions (see Chapter 4 for a detailed description).

TABOUT (IRT) - outputs the general information concerning the node being evaluated, and if IRT = 1, also prints the nodes on the branching list.

READIN - transfers the input basis to the file which the LP uses for storing its current basis on.

NXBRN (XT, SIGMAT, NXB) - determines the best branching candidate, NXB, given the present X-vector, XT, and the node information, SIGMAT.

TIMEC - determines how long the program has been running, prints the time or interrupts depending on whether or not this time is less than the input maximum.

GETASQ (NOES, ELM, JSQ) - orders the elements of the vector ELM, of length NOES, in ascending sequence, keeping the index variable, JSQ, associated with the vector in the corresponding sequence.

GETC (KCX, BLT, ULT, CT) - determines the slope of a straight line on the cost function from the lower bound, BLT, to the upper bound, ULT, for the KCX variable and stores this in the cost vector, CT.

PRESET - initializes core storage at beginning of the algorithm.

SET (TMMAX) - initializes the time limit which is used by the routine TIMEC by adding the limit, TMMAX, to the clock time.

PARAMS - reads and stores the information on the parameter and bound cards of the input deck.

LP

LP is the linear programming system driving subroutine which directs the overall solution stages through:

SETUP - which initializes all data for the A matrix files and the solution bookkeeping.

MAPIN - which introduces any prior solution known for the problem.

INVERT - which solves the problem equations to generate the current solution represented by the basis inverse and the values of the basic and key variables in the current solution, or an artificial solution.

PRIMAL - which solves the linear programming problem.

MAPOUT - which stores the solution found and loads it into the output vectors IX and X.

LP begins with the overall common definitions for the LP system, and must be loaded first since the common statements /A/, /B/, /CORE/, /ROWTYP/, /IXX/, /XX/, /NAMES/ overwrite the smaller dimensions specified in later subroutines which can remain unchanged regardless of problem size.

AJ contains the operating core columns and the complete basis inverse B at AJ(IØRG) = B(IORG), see below.

The first stage is to specify the A matrix files IA1 - used for the A matrix less GUB rows, INPUT - used as the source of the unpacked A matrix by columns, witten in binary, one column per record, and IMAP - used by MAPOUT, MAPIN and INMAP as a file for the BCD MAP cards defining the basis, initial and/or final.

Files IA1 and IA2 are specified as blocked. Meaning that each physical disc write or read is of as many columns as the buffer sizes for IA1 and IA2 will allow, and not just one column, as actual written in FORTRAN. This considerably reduces the disc access time denoted as PP time on the CDC 6400.

NWAJ, the number of words in AJ is used to compute the number of columns available in core.

The second step is to initialize the LP calling parameters with the LP calling arguments. The matrix generator locates the cost row

ICOST as the last row MROWS which is INPUTM for the linear program common/INPUT/. The right hand side is JRHS, placed as the last column NCOLS which is INPUTN for the common/INPUT/. The number of bounds NBDS is the number of changes NCHGS, the calling parameter, and the first NCHGS columns are bounded by BBCAV convention. The values of the bounds are in UBS.

The second stage ends with specification of LP system print and termination controls.

LP Cut-Off

STATUS terminates the program if any linear program takes longer than TMAX seconds or K5 iterations ITRN. The termination causes a MAPOUT allowing restart of the linear programming system but not necessarily BBCAV.

Diagnostic Snapshots

A snapshot of the current solution and column format can be had from XCHECK by setting K4 to

$$K4 = 1000 \times N1 + N2$$

giving a snapshot of iterations N1 through N2 inclusively. K4 = 0 suppresses XCHECK. The format is explained in the XCHECK subroutine writeup.

Print Control

This is achieved by K3.

K3 = 0 prints everything

K3 = 1 prints no LP system output except error messages.

Other values of K3 give a selective print of all or some of the respective outputs according to the prime factors of K3.

Specifically K3 should be a product of primes and

$$K3 = 2 \times 3 \times 5 \times 7 \times 11 \times 13$$

gives all print options. To obtain selective control:

1. To print the MAPIN cards as read K3 has factor 3.
2. Inversion diagnostic data from INVERT on infeasibilities of the current solution as found, the columns rejected during

an inversion or reinversion and the final infeasibility if any, K3 has factor 13.

3. MESSG prints linear programming system verb entry names and entry times and serveral messages if K3 has factor 7.
4. STATUS prints the status of the PRIMAL iterations at beginning and end of K3 has factor 11.
5. MAPOUT places a basis inverse B, IBASIS, KEYS and BETA representing Restart data sufficiant to avoid an initial invert on file INPUT if K3 has factor 2
6. MAPOUT prints the solution status in packed format when called if K3 has factor 5.

Thus to obtain printouts of inversion diagnostics, a mapout, verb entry times and status data set K3 = 5 x 7 x 11 x 13.

The third stage of the program LP calls the system verbs listed earlier.

The basis inverse is at B(IØRG) where IØRG is M^2 words down from the end of AJ, i.e. NWAJ. The remaining space in AJ is allocated to columns of which NCRMAX can be fitted in. There must be at least 5 columns slots available, three for CHECK to retain columns and two for work space. Fifty columns are recommended

Finally MAPOUT moves the current variable state to file IMAP, the solution to INPUT, the packed variable values to IXX and XX. IXX has the indices in ascending order of non-zero variables, and XX has the corresponding values. There will be between INPUTM and INPUTM + NBDS non-zero values followed by zeros.

Variable Lengths

In /IXX/, /XX/ IXX, XX should be set to 100 or INPUTM + NBDS if larger.

In /CORE/ AJ should be big enough to take the basis inverse $(INPUTM+1-L)^2$ words plus 10 to 100 columns at (INPUTM+1-L) words each where L is the number of GUB rows.

In /ROWTYP/ IROWTP should be 100 or INPUTM+1 of larger than 100.

In / NAMES/ NAME should be 100 or INPUTN+1+S if larger, where S ≤ INPUTM is the number of inequalities and free rows.

In /A/ ALPHA should be 100 or INPUTM+1 if larger.

In /B/ BETA should be 100 or INPUTM+1 if larger.

All other commons are correctly sized in LP.

EXISTS

All exists from primal are via the subroutine EXISTS for the purpose of user parameter settings.

SETUP

This subroutine is the system verb which has the task of initiating the LP system when starting from scratch.

SETUP first of all initializes all LP system parameters, then examines the row types constructing a logical or slack column for each nonequality row and writes these to disc using calls to OUT of IO. An extra free row is incorporated for the phase 1 cost row and the logical columns for free rows are marked basic.

SETUP then reads the A matrix columns from the binary INPUT file and writes then out to disc using calls to OUT of IO. For each column the NAME vector is set to record the column type (free/null), the column GUB packet number or zero and the column bound index or zero. The right hand side vector is recorded in core in RHS.

Finally, SETUP rewrites IBASIS and the RHS vector to place the GUB row elements at the end. The count of GUB rows is recorded in L and the actual row count is reduced by L. The cost row marker ICOST is reset to its new position in the rearranged rows.

IO

This subroutine handles all disc to core transactions and keeps track of column bookkeeping.

OUT writes two files of columns of the A matrix writing one column in each file per call. The first file IA1 contains columns less their GUB elements. The second file IA2 contains columns less their GUB elements and any zero elements and is written in a packed format.

IN reads file IA1 cyclically up to NT times, in search of a particular column rewinding when appropriate. It is normally accessed for sequential columns by CHECK but INVERT uses it to locate basis, at-bound and key columns marked in the NAME vector.

INPCKD reads file IA2 cyclically up to NT times in search of a column rewinding when appropriate. It is only accessed in random forward increments searching for key columns and thus uses a packed file.

After NT reads, sufficient to locate any column, both entries cause an error message and dump.

Once IN or INPCKD have located the required column and read it to a slot in AJ( ), the column index is loaded to the corresponding position in JA, its reject memory in JAREJ is cleared and its mnemonic (unused) is placed in JAK.

Thus it is not possible to read a column into core without adjusting the bookkeeping of what is in core.

MAPIN

This subroutine is the system verb which sets the bookkeeping of the column status and allows a restart from a previous status. It is designed to read a file IMAP generated by MAPOUT and loaded by INMAP to file IMAP.

MAPIN reads settings of NULL, BASIC, KEY and ATBND designated at random one type per card up to 4 columns per card for each type. Each type sets the column status marker in NAME appropriately.

Restarts

MAPOUT writes the LP system status onto the end of the INPUT tape file when MAPOUT is called, and provides an INVERSE card for MAPIN use. The INVERSE card causes MAPIN to check for an inverse plus bookkeeping data and the solution status on the INPUT tape, and read it if present.

INMAP

Is the entry designed to read the input card stream for MAPIN cards and load them onto file IMAP. It is terminated either by an end of file or and END card.

Manual preparation of MAP cards is possible and extensive checks in MAPIN will detect and avoid most errors.

INVERT

This is the system verb which inverts or reinverts the current basis as defined in NAME records and completes the basis with artificials.

When INVERT is called, an inversion occurs only if the current iteration exceeds ITNINV. When it does ITNINV is increased by INVF, and an "INVERT" message is printed.

INVERT first clears the basis records and the GUB packet basis column count, sets up a unit basis and for each GUB row without a key chooses the first valid GUB packet column as key. It then cycles the column status records in NAME until it locates a basic, key or at-bound column, which is retrieved by IN. Key and at-bound columns are accumalated in GAMMA scaled by their packet righthand sides (if keys) or their bounds. If basic columns are in a GUB packet, the key is located by INPCKD, subtracted from the column and the result transformed and pivoted into the basis in a row determined by PIVOT.

When all NAME records have been checked and the columns incorporated or rejected by PIVOT, the basis record is completed with logicals or if necessary with artificials. The artificials are then constructed in DELTA transformed and pivoted into the basis. Finally, FEASCH is called to construct and check the solution feasibility.

NB. The MAPIN used can be partial, complete, redundant or nonsense.

FEASCH

FEASCH is called by INVERT to compute $\beta = B^{-1}\gamma$ given γ in GAMMA and B^{-1} in B. The resulting β elements in BETA are checked for feasibility and the basis is adjusted if infeasible until the resulting BETA is feasible and the phase IPHASE is 1 or 2.

The method is to cycle each element of BETA from 1 to M, compute it, check if it exceeds a bound then check if it is positive. If it exceeds a bound, the basic column is set "at-bound," and the bound is subtracted from that BETA(I) which then becomes negative and infeasible. If it is negative i.e., infeasible, its sign is reversed and the column is replaced by its negative artifical*, to pick up the infeasibility directly, (the artificial need not be transformed) and pivoted into the basis in place of the old basic column. Finally, if GUB rows are present the last L entries in BETA are filled with the values of the key variables.

Feasibility of the keys is maintained by calling KEYCH to move the infeasible key (essential packet) to a basic position in a non GUB row and processing it as above as an infeasible variable.

If any infeasibilities have been encountered, or the resulting Phase 1 cost is larger than CTOL, Phase 1 initiates otherwise Phase 2.

---

* The negative artificial of a column A_j is $-A_j + e_m$ is the mth column of the identity matrix. The negative artificial of an artificial $e_i + e_m$, is $-e_i + e_m$.

PRIMAL

This subroutine is the main LP verb which solves the LP problem phases 1 and 2.

PRIMAL notes its entry and time using MESSG, then picks up the cost row for its current phase 1 or 2, the appropriate π row in the inverse and sets the phase 1 row to free in phase 1 or equality in phase 2.

The basic solution cycle is counted by ITRN. If ITRN exceeds K5 or if CP time exceeds TMAX a MAPOUT is called by STATUS followed by EXIT.

The solution cycle proceeds with COLUMN to find an in-core column JCOL. If JCOL = 0 no column is found and the phase terminates. If the cost is zero in phase 1 this is the feasible solution termination, if phase 2 this is the optimal solution, if non-zero in phase 1 there is no feasible solution.

Next ROW is called for a pivotal row IROW. If IROW = 0 no row is found and the problem is unbounded.

Next the pivotal element is checked for size and degeneracy. If it is too small NREJ is indexed. If 5 bad columns have occurred an INVERT is called to check the inverse. If more than 100 bad columns have occurred the problem terminates either in phase 2 as optimal, or with a dump. If the pivotal element is okay, the cost change THETA * DJ(JCOL) is checked. If this is smaller than CTOL, NDEG is indexed. If more than NDEGLM degenerate columns have occurred and there are no more good columns the column is accepted. Otherwise in either case the old column is rejected and a new column is selected by COLUMN ignoring the previous selections.

Next the step is saturated to the bound on the column. If it exceeds the bound and the column is not at bound, the column is set ATBND. If the column is ATBND, the column is set free. In either case there is no pivot and the solution is corrected for the bound change but there is no basis change correction and NREJ = 1 to suppress pricing in the next iteration.

If the step is within the bounds, a basis change will be made. The rejected column is located first in the basis of IROW $\leq$ M, then in the keys of IROW > M. If IROW $\leq$ M there is no key change, the new

column is pivoted in by PIVOT at IROW. If the new column is AT BND the step is off the bound and the new column value EPSI is corrected to the bound value less the step. Then the new column is made basic, the rejected column is made free, and the solution step made and the new basic column value set to EPSI.

If IROW > M there is to be a key change. If the GUB packet is essential, it has other basic columns and the key is changed for one of these using KEYCH, then IROW ≤ M and the previous case follows.

If the GUB packet is not essential it has no basic columns, so the key is changed to the new column and the old key is dropped. The new key value EPSI = THETA and a normal step is made as before without a pivot and pricing in the next iteration is suppressed.

After every pivot the rejected columns are cleared.

At the end of the iteration cycle STATUS reports the solution change.

After every row and column selection, or at any optimality stage, XCHECK is called for a debug which occurs if K4 is set > 0. See LP for details.

STATUS

STATUS prints out the status of PRIMAL iterations every cycle under the headings.

PHASE = (IPHASE) - the LP phase 1 or 2.

ITER = (ITRN) - the LP iterations count.

TRY = (NTRY) - the number of iterations with the same set of columns in core + 100 x maximum number of tries.

VAL OBJECTIVE = (BETA(IC)) - the solution value of the current cost row.

NDJS = (NDJS) - current count of negative DJ's an estimate of non-optimality of the current core columns.

NARTS - the current number of artificial vectors present.

VALUE DJ IN = (DJ(JCOL)) - the value of the DJ for the column chosen to enter.

COL IN = (JPØS) - the internal number of the column chosen to enter.

CODE = (NAME(JPØS)) - the status of this column.

COL OUT = (JOUT) - the column rejected.

CODE = (NAME(JOUT)) - the status of the column.

NSCAN - the current number of rewinds of file IA1 the A matrix plus the number of columns active in core, or columns read on disc.

Note: If JOUT is zero, no column was rejected and its code is zero.
If JCOL is zero or IROW is zero, these are taken as termination markers and the NOTE obtained in the STATUS call is printed e.g. PRIMAL--END, etc...
If JOUT > NT artificial code is constructed equal to the 10^8 x IROW.

ROW

This subroutine is called by PRIMAL to locate the pivot row IROW in the selected column JCOL.

ROW first transforms the in-core column JCOL to the current basis representation in ALPHA, reconstructing the complete column including GUB elements which occupy the last L positions.

The row selection depends upon whether the column is at-bound or not, for if at bound the column represents the slack vector and the step is negative. For either case the minimum THETA is found which

(i) drives the resulting solution to zero or

(ii) drives the rejected column out at bound, depending upon the sign of the potential pivot element ALPHA(I).

These are case 2 and 3 for a normal column and cases 3 and 2 for an at bound column. Upon exit THETA is the step in row IROW, core-column JCOL, (JPØS on disc) and ITYPE is 2 or 3 for the type of step.

If no row is found IROW = 0, ITYPE = 1 indicating an unbounded step and THETA = 1·E35.

COLUMN

This subroutine locates a potential column entry JCOL from those in-core, or calls CHECK to search all or part of the disc for more columns and uses these.

COLUMN counts NTRY selections with the current columns. If more than NCRMAX, or no columns exist in core it locates up to NCRMAX new columns with a call to DISC. If no columns are found the problem is optimal and JCOL = 0 at exit.

The in-core columns are then priced out, unless no pivot has occured (NREJ or NDEG $\neq$ 0) because of column rejection or DISC has just been called. PIKEY is always set to the current key price for the packet recorded in JPKTO. If a column is in a packet, its price is adjusted for the key price. All columns are priced apart from rejected columns.

The best unrejected column is now found by searching the DJ values. At bound columns have DJ reversed as they correspond to the slack column, and the number of negative DJ's is counted in NDJS.

If no good column is found, i.e. the best DJ is above the DJTOL threshold, DISC is called to search for more columns unless these columns are new, denoted by NTRY = 0 (no selections with these columns).

Upon exit JCOL is the in-core location of the best column found in-core (or from disc) called JPOS, or JCOL = 0 denoting no column. If JCOL = 0, JNCORE is reset to the number of columns in core (because DISC has deleted the count of columns that were there) in order to try to save a disc read in the next phase if any.

DISC

This subroutine checks the disc for more columns and selects those which are currently "not bad."

First DISC calls INVERT to see if the iteration count ITRN has exceed the next invert point and inverts if necessary.

DISC reads the columns in batches of NBCH columns serving 1 column/batch. If fewer than NCRMAX columns are actually used these are read directly into core where they stay, once and for all. Alternatively the current file IA1 position JNT is found by INPOS and DISC examines the columns starting at JNT + 1, proceeding cyclically, changing batch every NBCH columns. If the new packet number PKT is different and nonzero the new key is located and read over any unused old key, or into the next vacant AJ slot, by INPCKD.

The column type is found in JTYPE and null (0), basic (2) and key (4) columns are skipped. Free (1) and at-bound (3) columns are read by IN to the next location JORG. The new column is priced out correcting for its packet if $\neq 0$, and if the new price DJNEW is worse ($\geq$) than DJOLD (the best of the current batch) the column is skipped. Otherwise this column is preserved as IORG in the batch records and the best batch column DJ as DJOLD.

Every NBCH column, column IORG is saved if it is better than DJTOL and IORG is reset to the next vacant column.

DISC will work if the packets are disjoint, (separated by zero packet columns), and also if the packets are mixed up, (alternate columns in different packets) but with much loss of efficiency due to multiple key searches and rewinds of file IA2.

DISC always pulls in the key of each packet first for each packet, using the packed file IA2 regardless of where the key is located in the packet.

Subroutine KEYCH

Changes the key for an essential GUB packet, to one of its basic columns in the packet, selecting the first one. The basis inverse, B, solution in BETA and current column in ALPHA are corrected for this rearrangement.

Subroutine SETBND, SETBNB, SETNNN, SETKEY

Sets and unsets the state of a column J in NAME (J), to either free (1), null (0), basic (2), at-bound (3) or key (4), respectively.

Function DOT, DOTS

Computes the inner product x'y in either double and single precision, respectively.

Subroutine MAPOUT

Writes the states of the null, basic, key and at-bound columns onto BCD cards, placed on file IMAP, and also places the current inverse B solution BETA and basis bookkeeping IBASIS and KEY onto the end of input tape INPUT to allow instant RESTART.

Function BOUND

Returns the value of a column bound, if bounded, or 10^{70} if unbounded, or artificial.

PIVOT

This subroutine pivots a new column ALPHA into the basis inverse B at row IROW. If IROW is zero the best pivotal row is found.

IROW is zero the basis is checked for empty slots or slots containing the column disc index JPOS. If the latter is found, this row is used as IROW since this is SETUP's method of fixing logicals for free rows. For null basis entries PIV and IROW track the largest ALPHA element and its row, and this is used as the pivot element unless it is less than PIVTOL where upon the column is dropped with IROW = 0 as a marker.

If IROW is non-zero, the pivot ALPHA (IROW) is checked against the PIVTOL for possible errors. If the pivot is not unity, the inverse row IROW is normalized by the pivot. Then for every non-zero ALPHA entry at I, that multiple of the inverse pivot row is subtracted from the Ith inverse row (skipping the pivot row).

KEYFND - function

KEYFND find the location in core of the key column for the specified packet. If none is found in core it returns a value zero.

If the calling argument is zero KEYFND locates any key in core which has no associated GUB packet columns. If no key is found in-core it returns a value zero.

Otherwise the value of KEYFND is the column location 1 to NCRMAX.

ESCAPE

ESCAPE causes termination with a snapshot of the working core followed by a call to file 0. This will generate an abort condition suitable to generate a system dump. If it is desired to do this, use:

```
DEBUG.
LGO.
EXIT.
DMP (LP, ESCAPE)
7
8
9
```

This will dump the core using the labelled system dump from subroutines LP to ESCAPE, which should be first and last respectively.

Consult the variable list for a definition of the global variables.

All calls to ESCAPE are preceded by an ERRØR message of explanation of the fault condition.

XCHECK

XCHECK delivers a core snapshot if ITRN lies between N_1 and N_2 where K4 = 1000 N_1 + N_2. (K4 = 0 suppresses XCHECK.)

XCHECK prints using the following format.

(a) Col 1 indexes the normal and GUB rows respectively.
(b) Col 2 prints the basis IBASIS and KEYS respectively.
(c) Col 3 is the current column representation ALPHA of JCOL.
(d) gives the pivot position IROW.
(e) Col 4 gives the current basic and key variables respectively.
(f) step is THETA the proposed step, before bounding.
(g) the column bound.
(h) the selected column disc index.
(i) is the list of core-column disc indices.
(j) Col 5-14 is a list of 10 columns around the selected column in their current basis representation.
(k) is a list of the column name codes at the XCHECK instant.

REPORT GENERATOR ROUTINE DESCRIPTIONS

REPGEN - the main program acts principally as a control program calling other routines to perform specific functions; determines if all solutions have been interpretted and initializes storage for each solution.

SETUP - reads input deck and reference list file into core storage.

INSOLN - interprets the meaning of each column in the solution and stores its value in the appropriate array(s).

YRCOST (J) - same as in matrix generator.

VALUES (N, ISTART, IEND, VAL) - determines cost information associated with each "X" or "W" type column in the solution; N is the number of the vehicle type, ISTART is its first year of existance, IEND is its last year of existance, and VAL is the number of those vehicles.

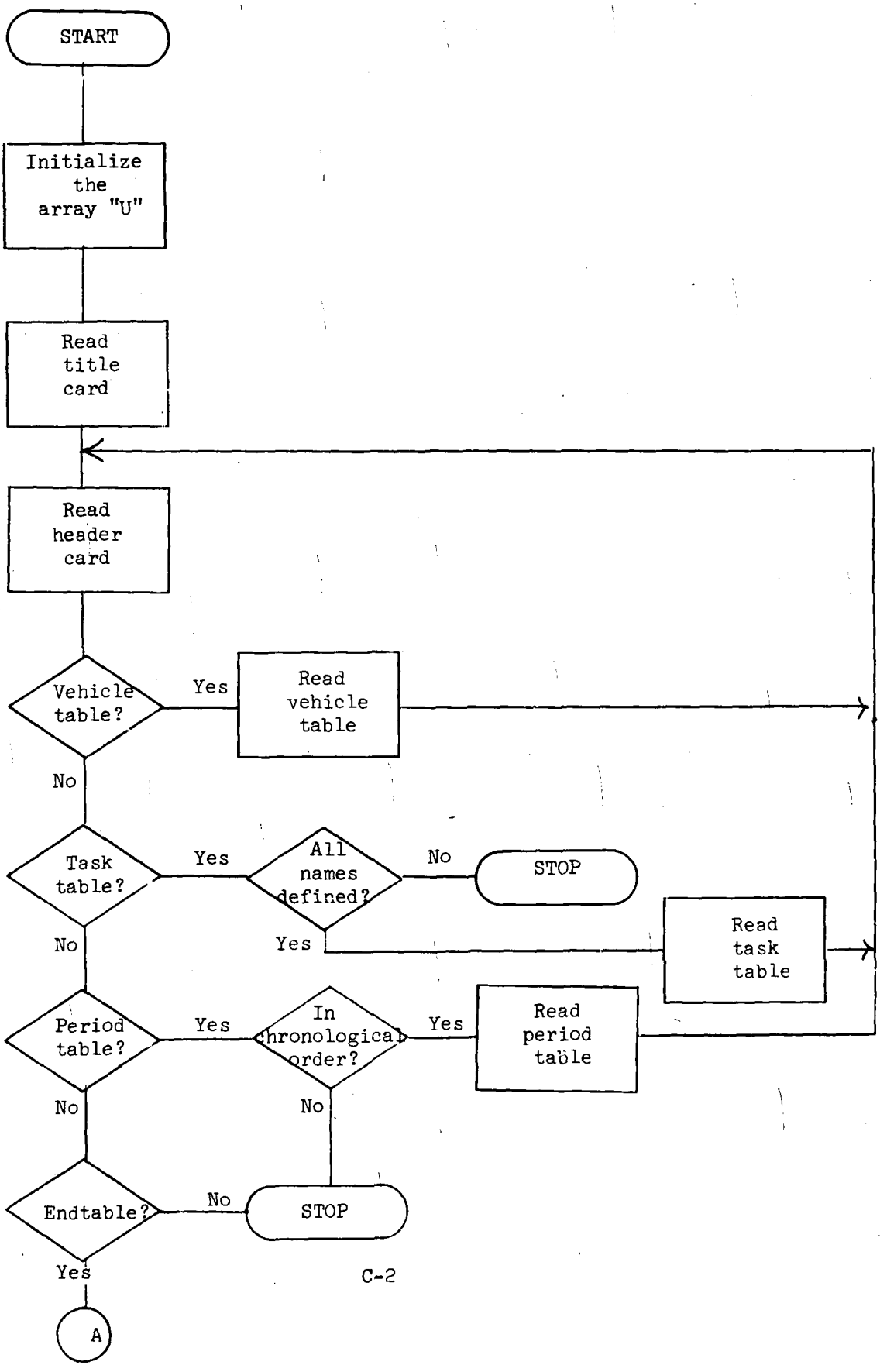
CINFO - this routine organizes, tabulates and outputs the table of cost information.

PINFO - this routine merely formats and outputs the last three tables of information; purchased resources, stored resources, and total resources used.

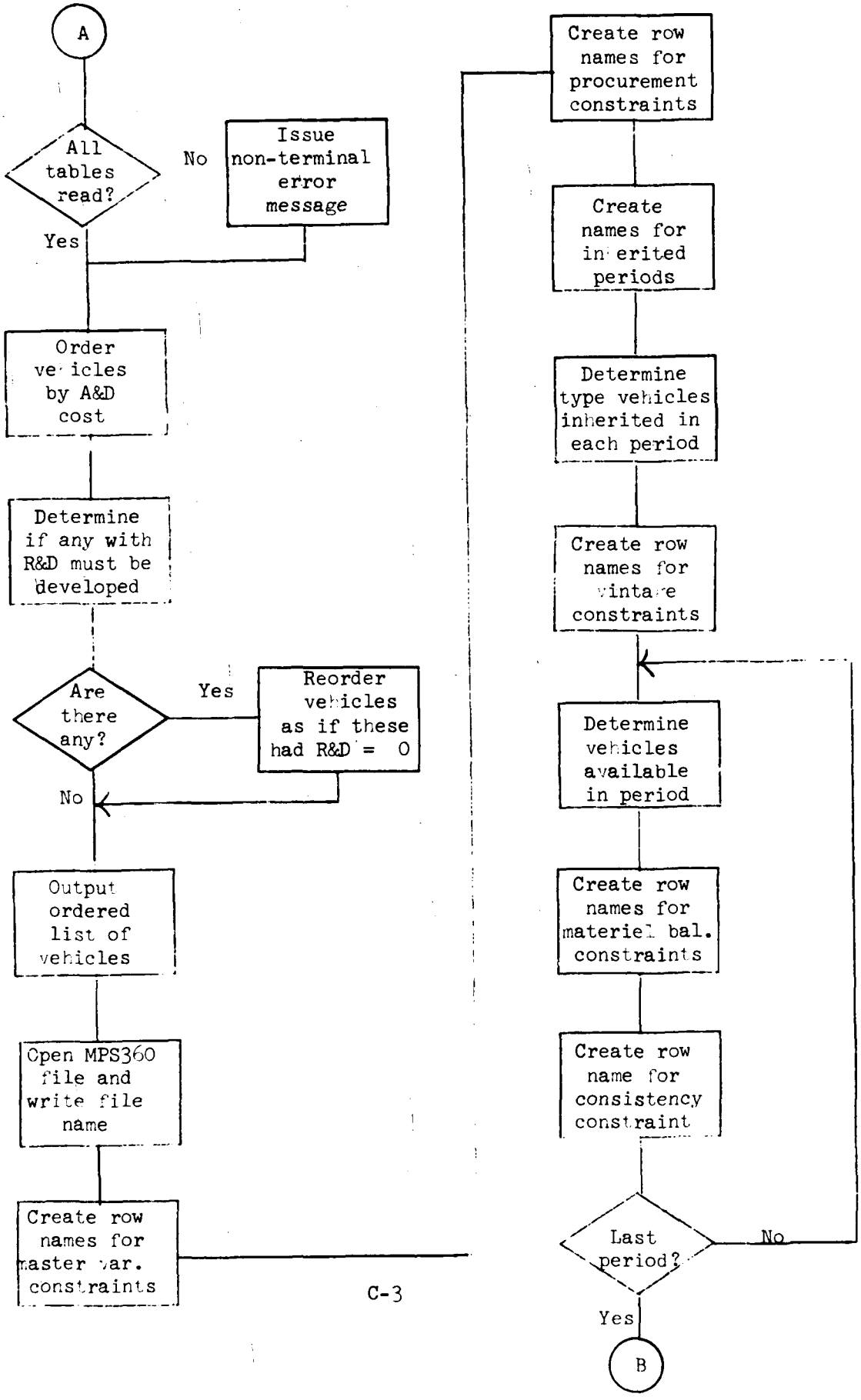
APPENDIX C

FLOWCHARTS

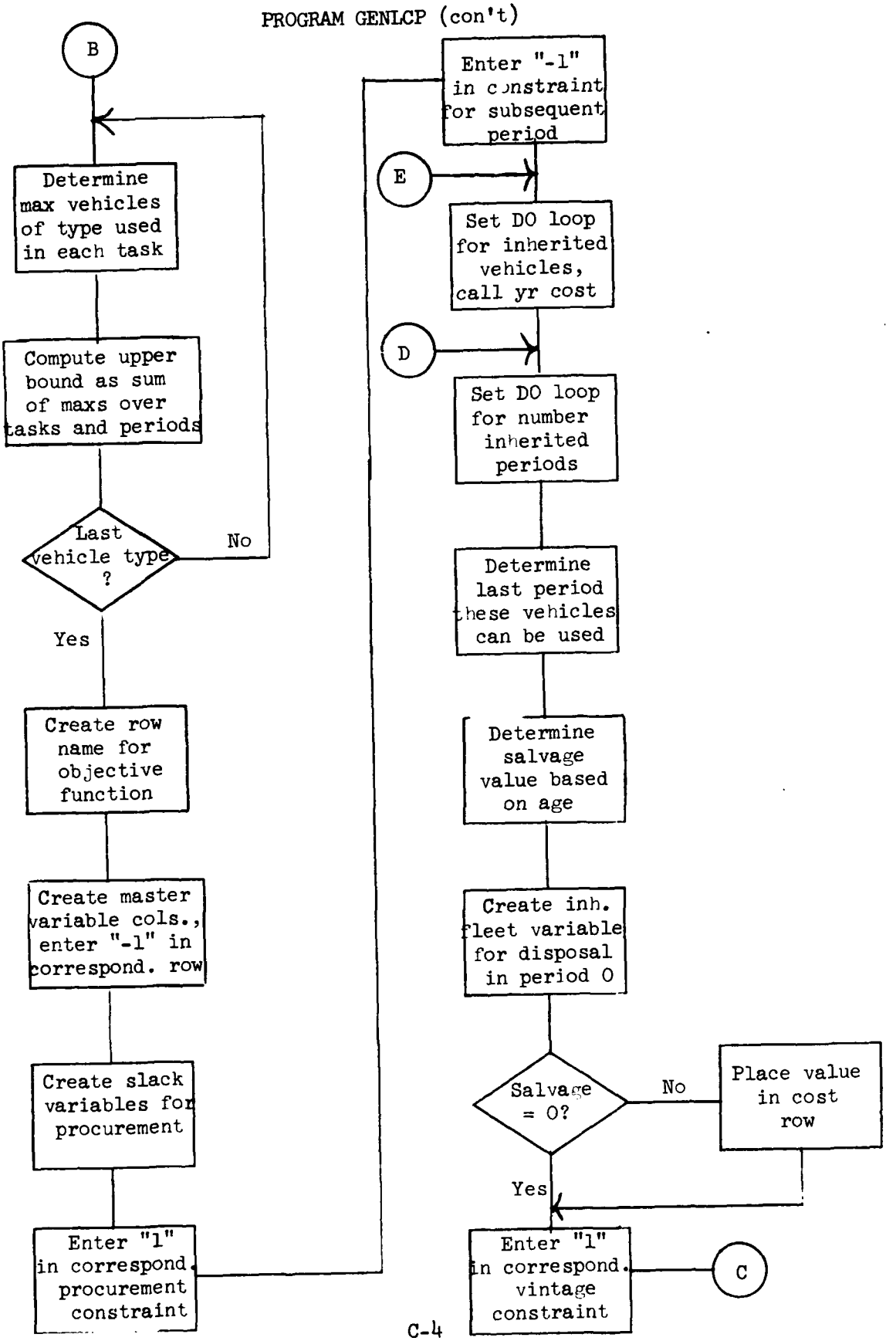
PROGRAM GENLCP



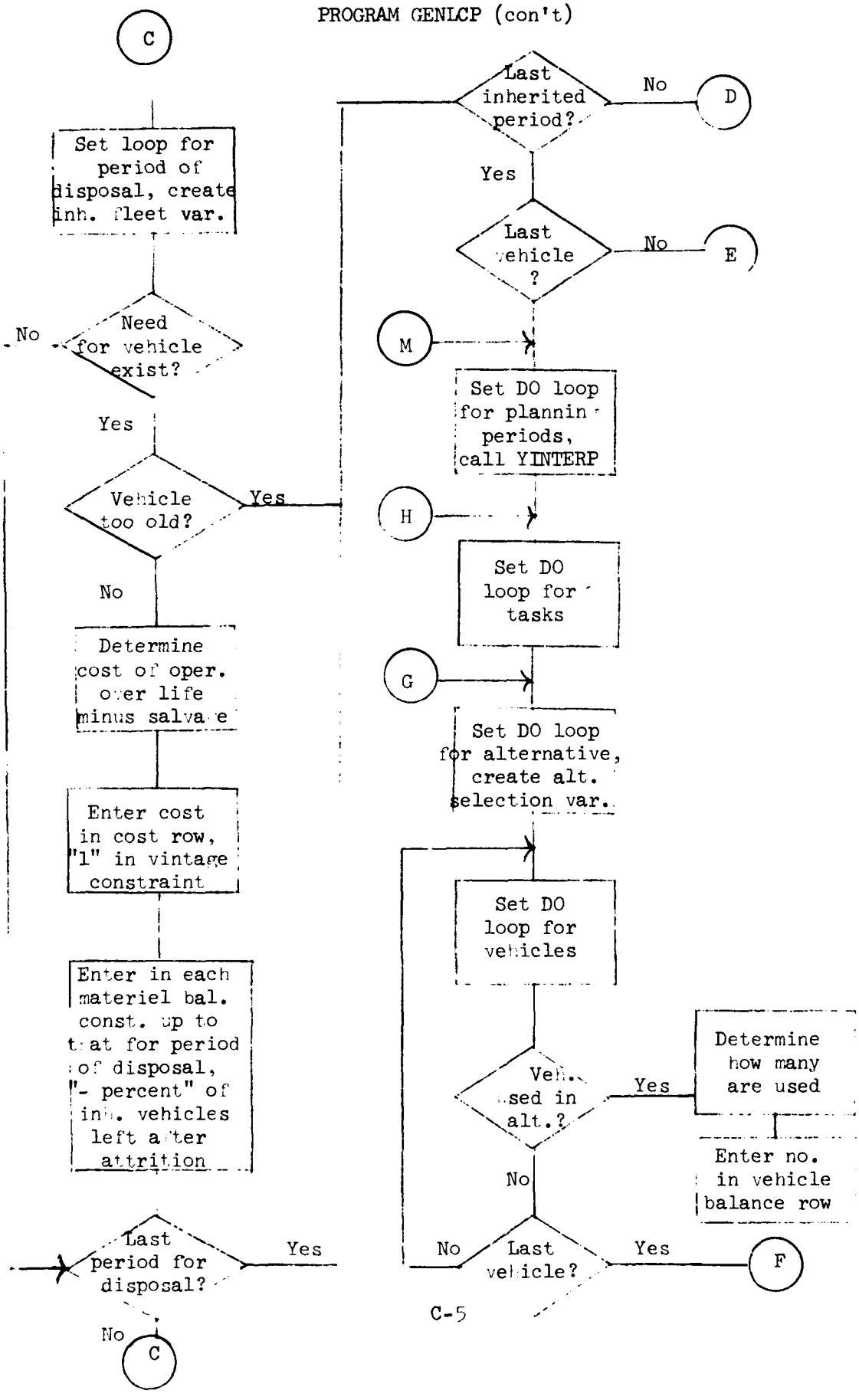
PROGRAM GENLCP (con't)



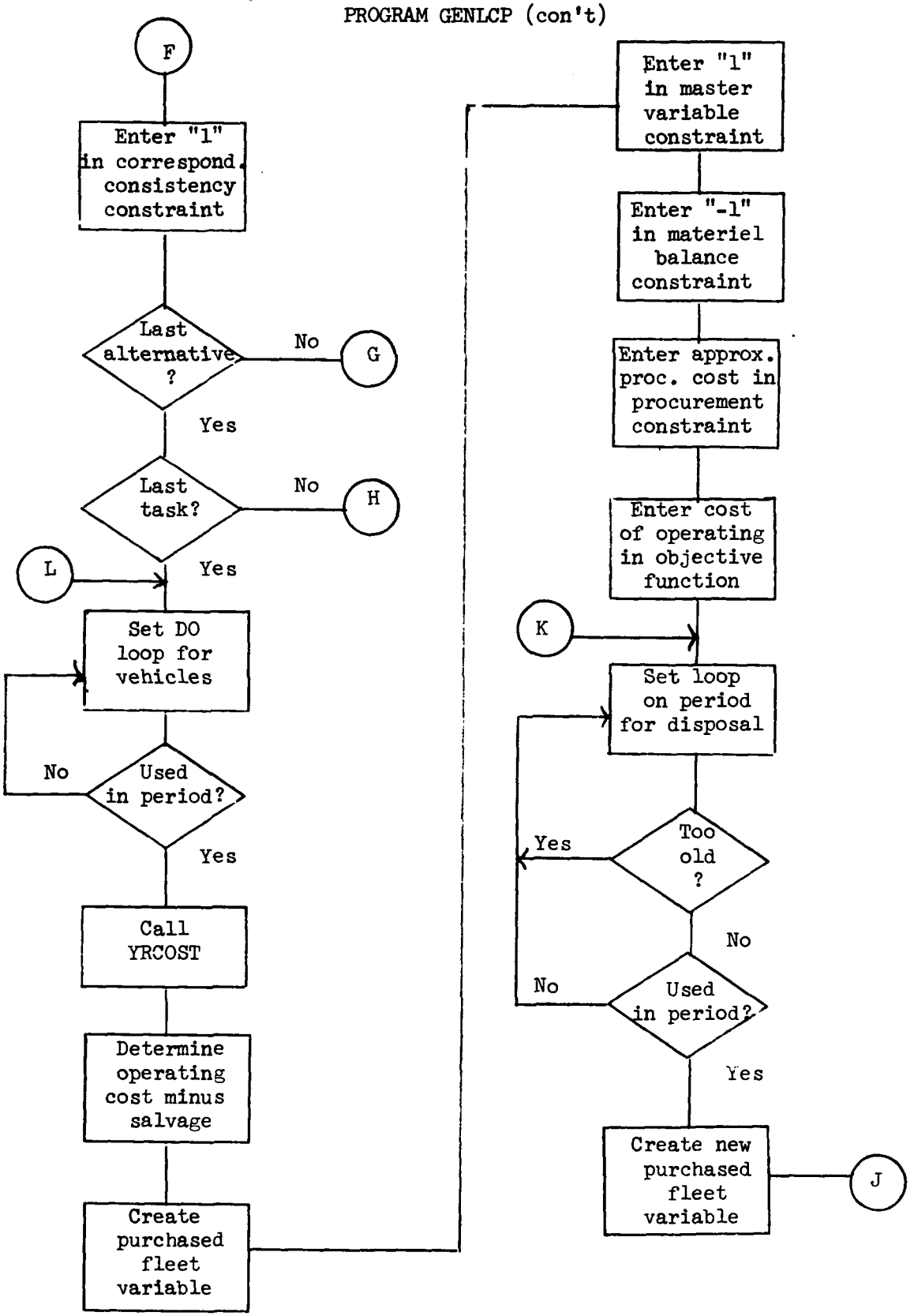
PROGRAM GENLCP (con't)



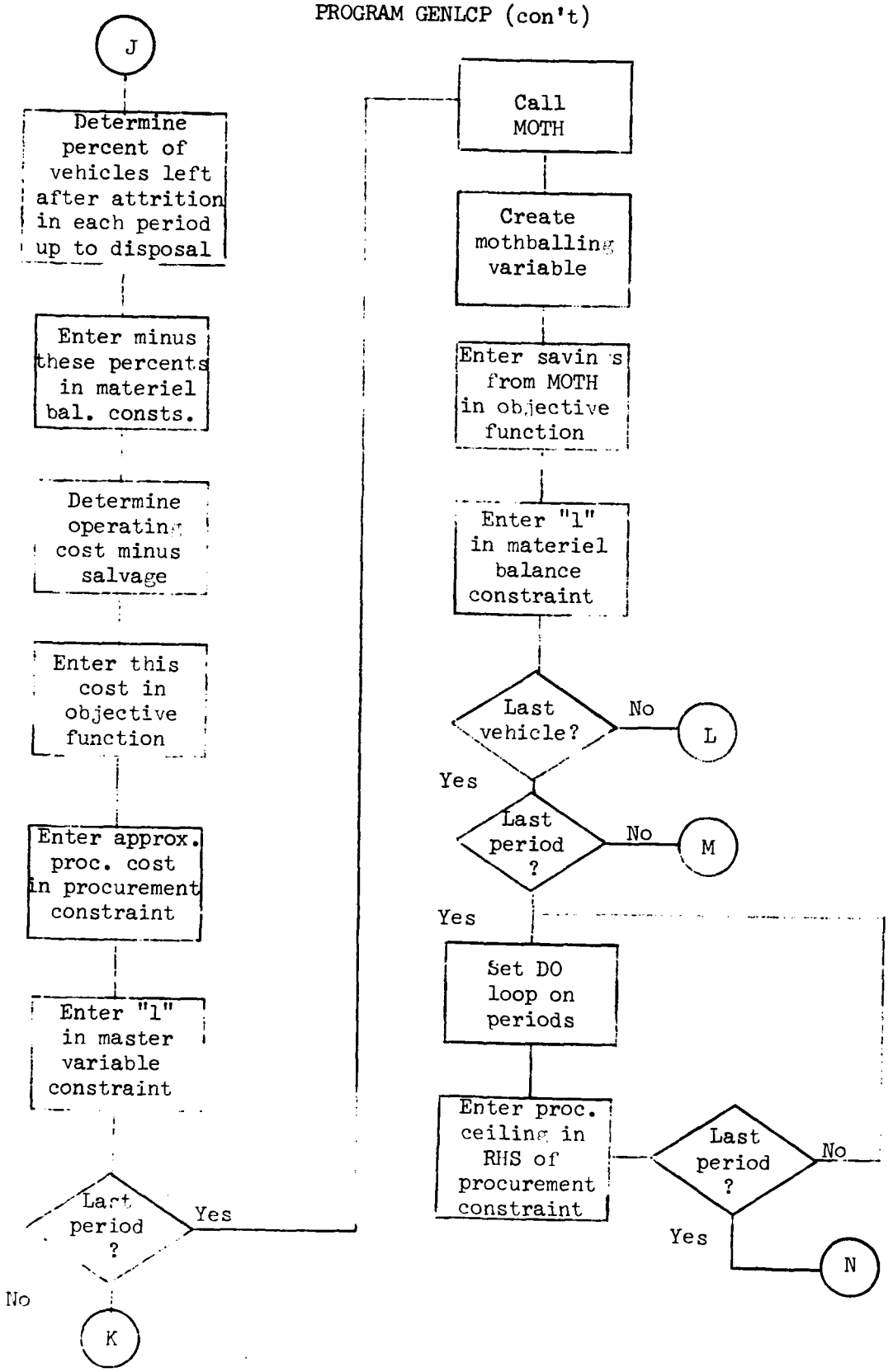
PROGRAM GENLCP (con't)



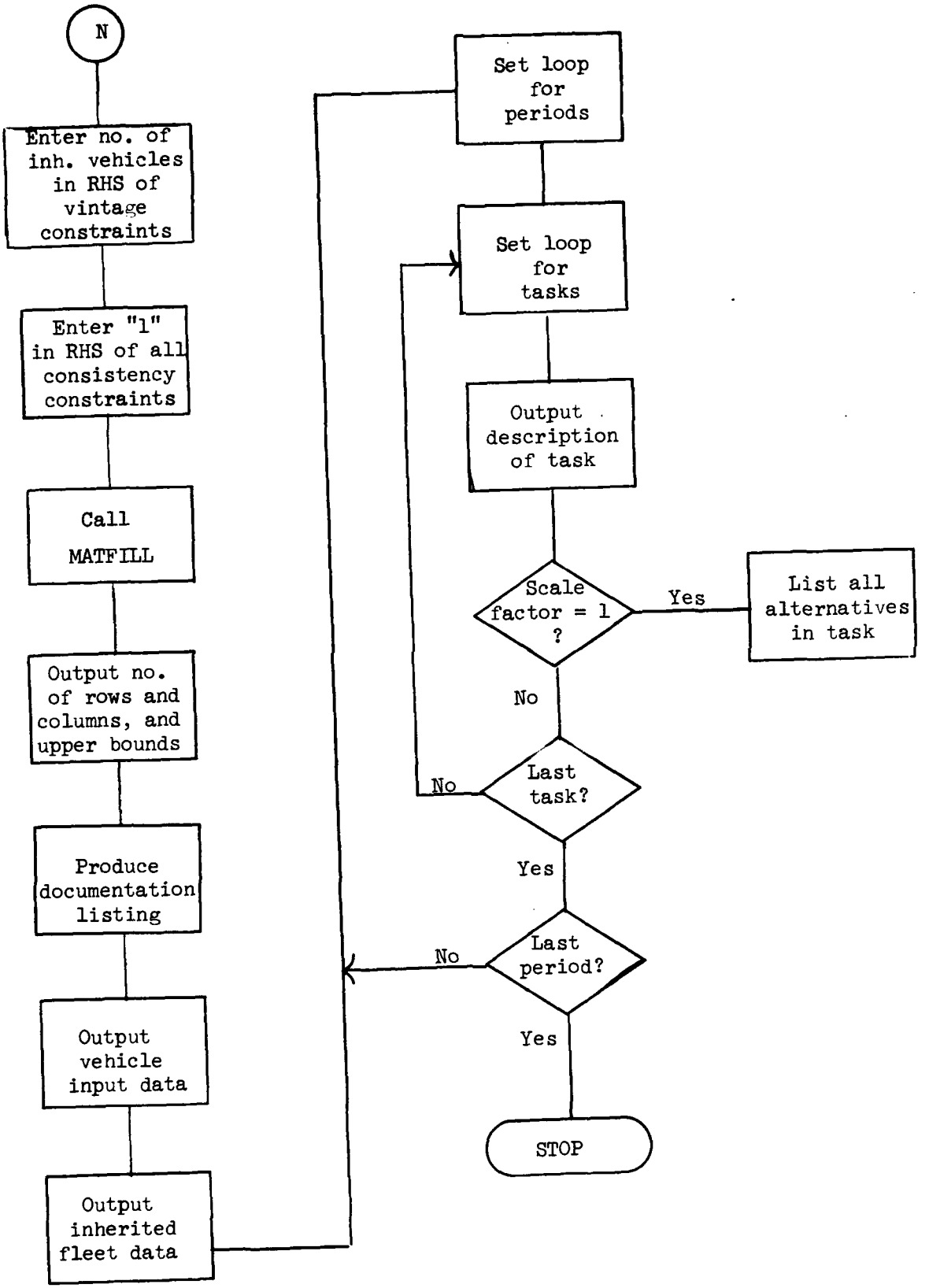
PROGRAM GENLCP (con't)



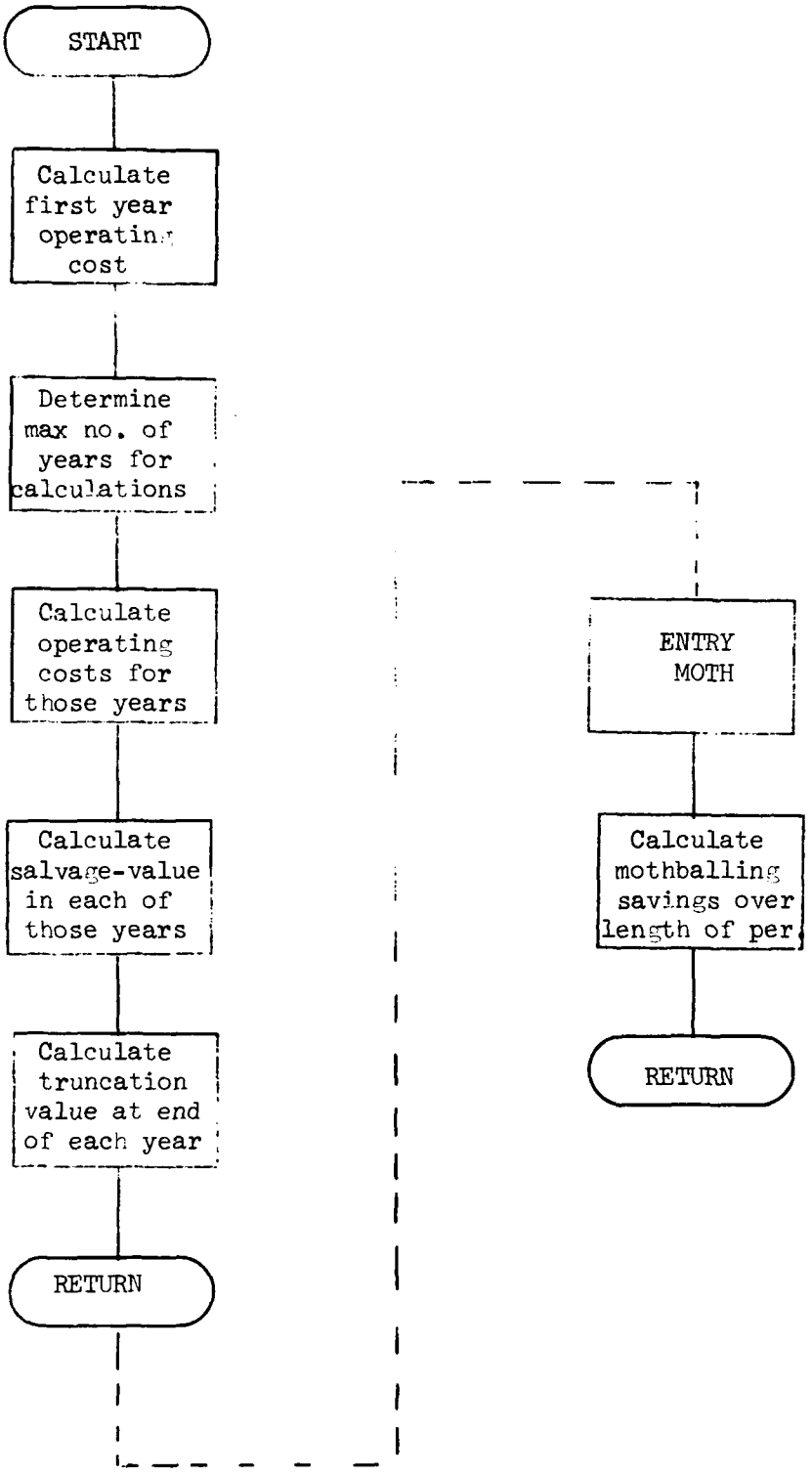
PROGRAM GENLCP (con't)



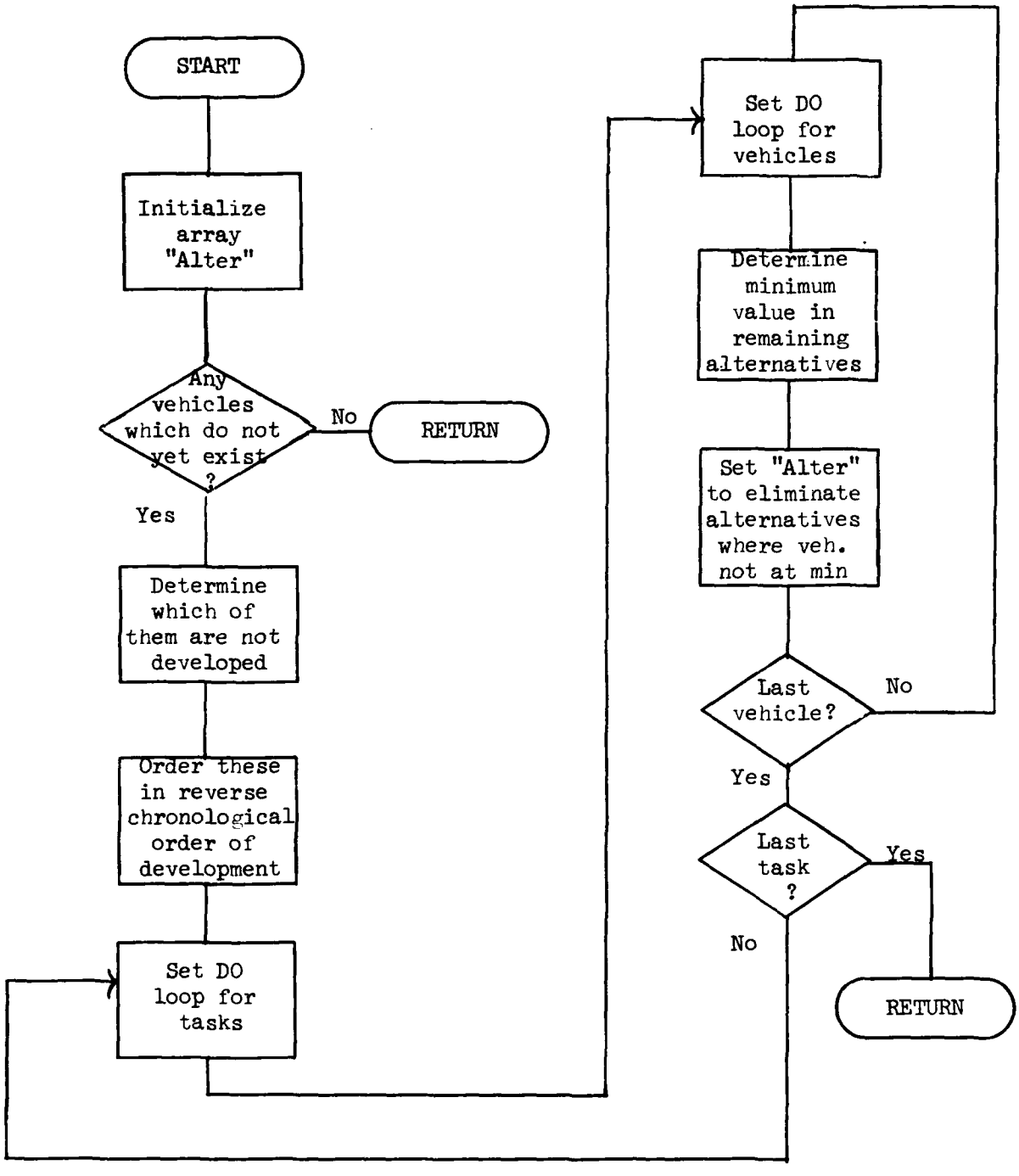
PROGRAM GENLCP



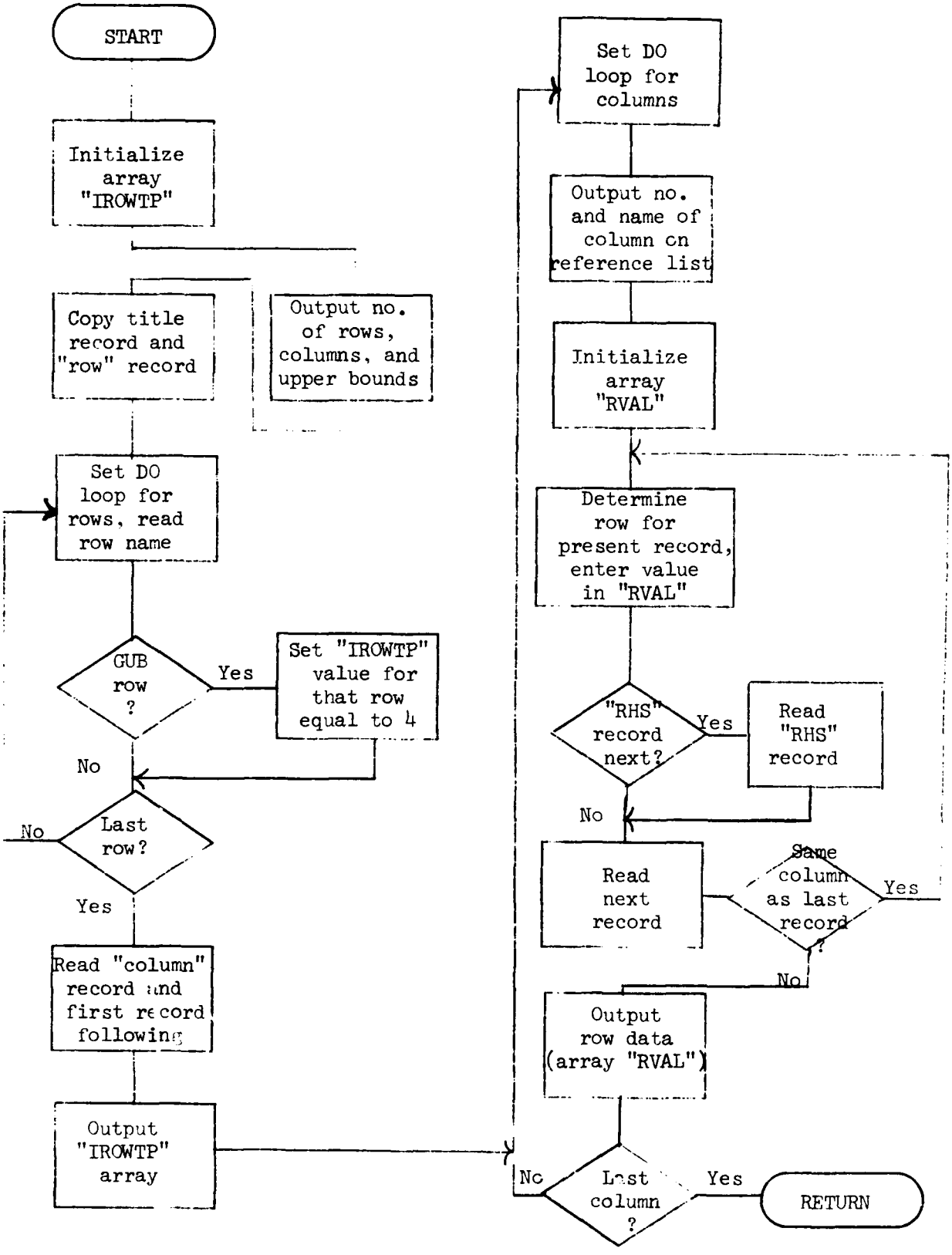
SUBROUTINE YRCOST



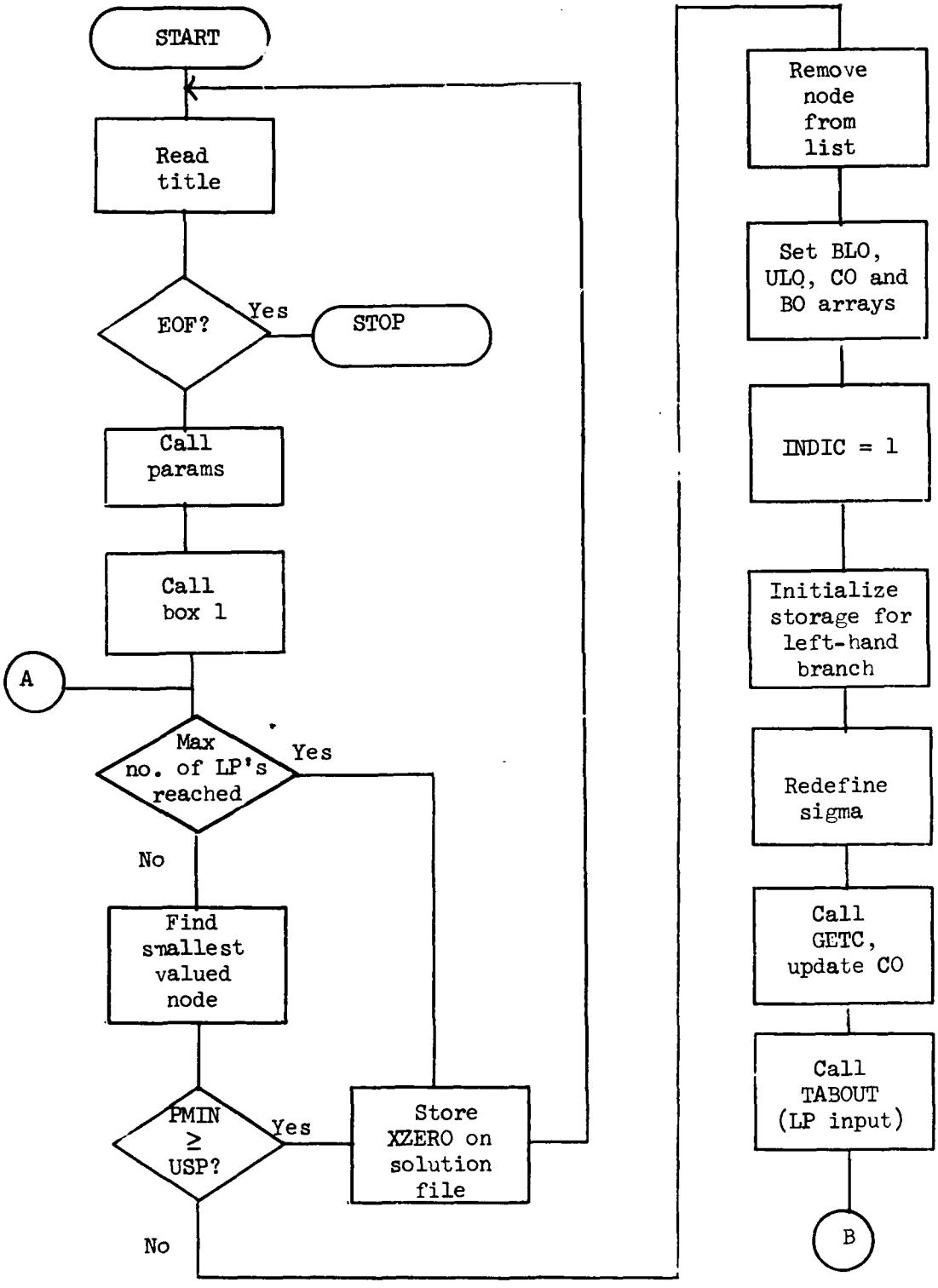
SUBROUTINE YINTERP



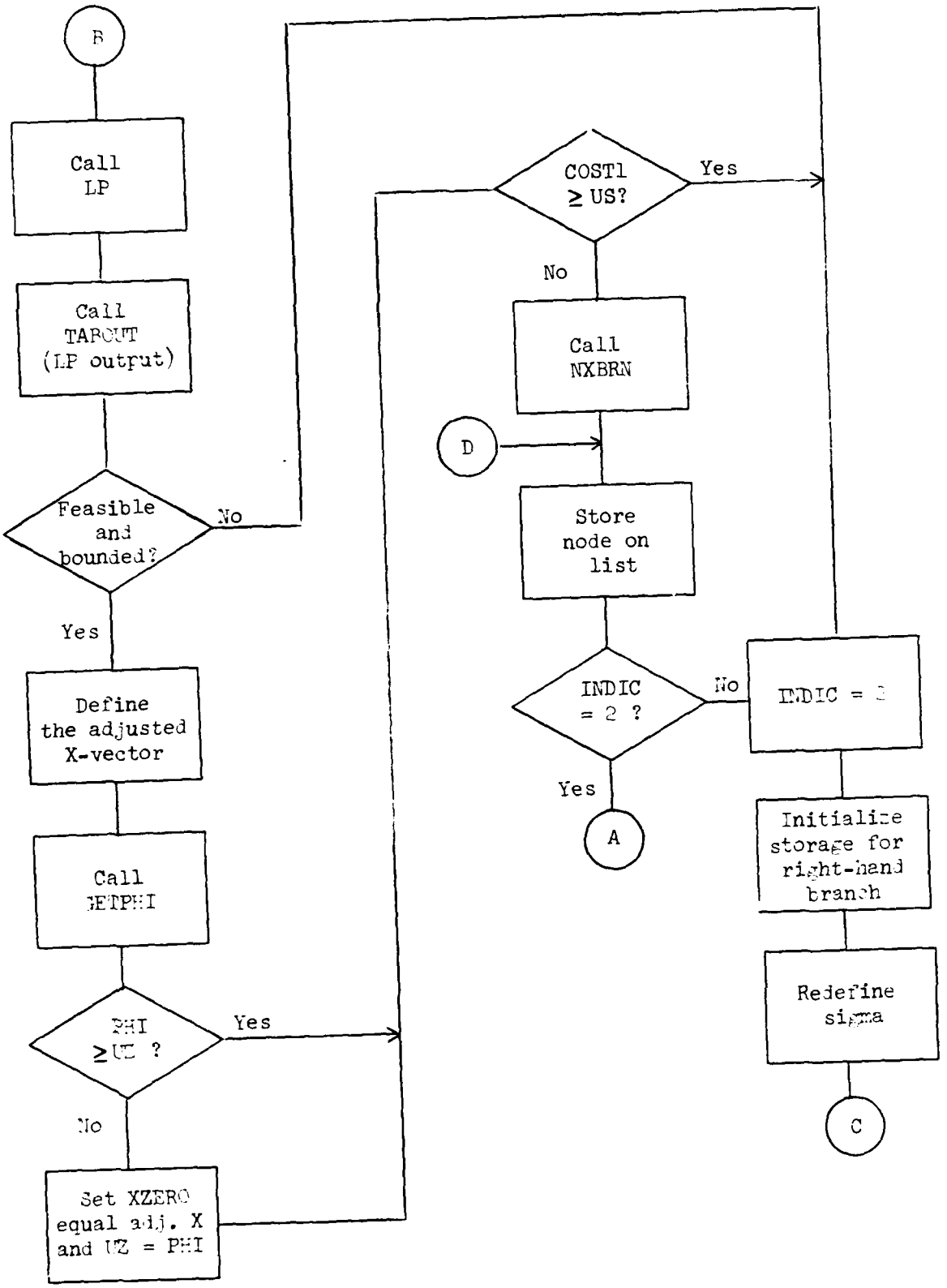
SUBROUTINE MATFILL

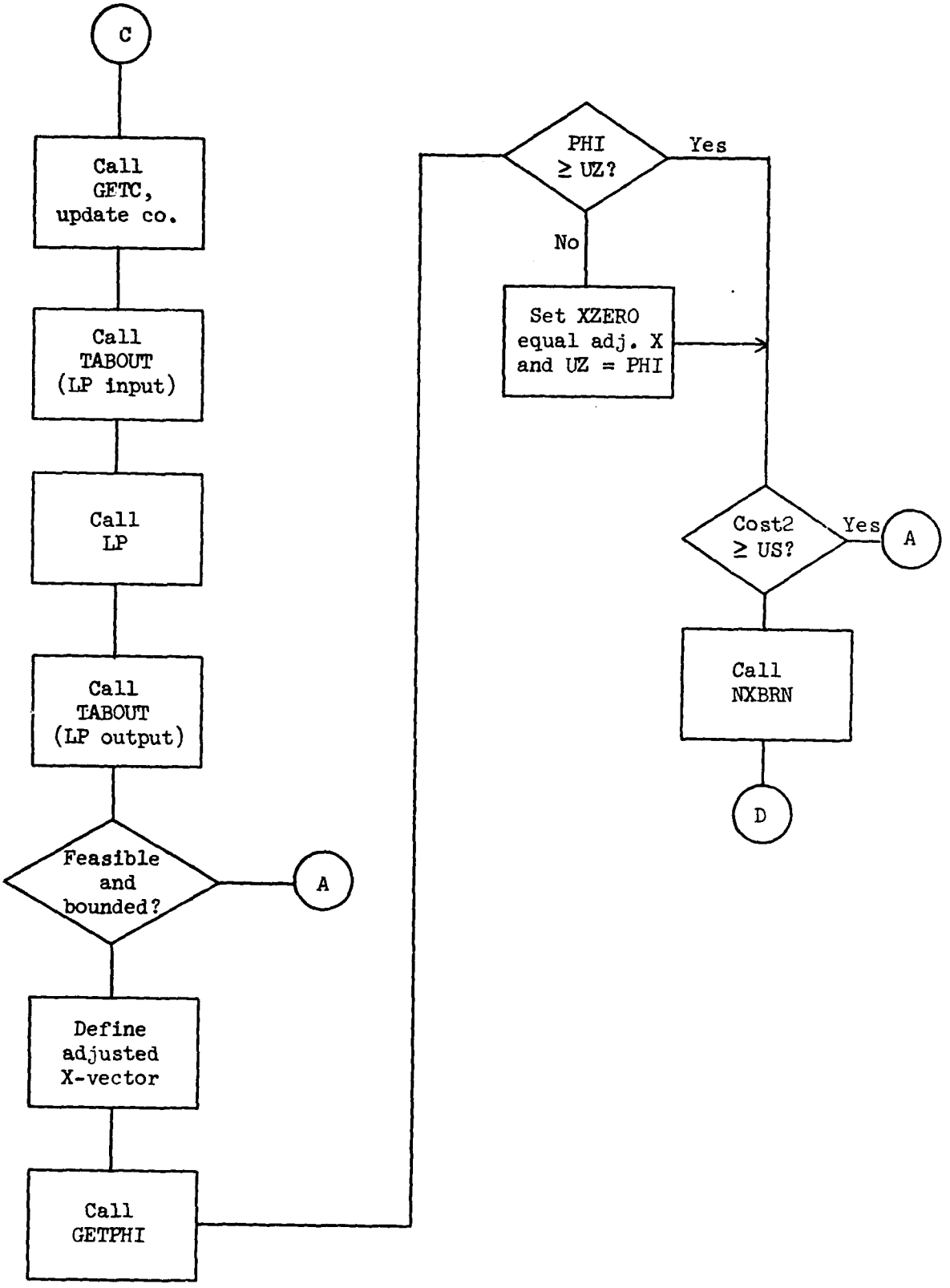


PROGRAM BBCAV2

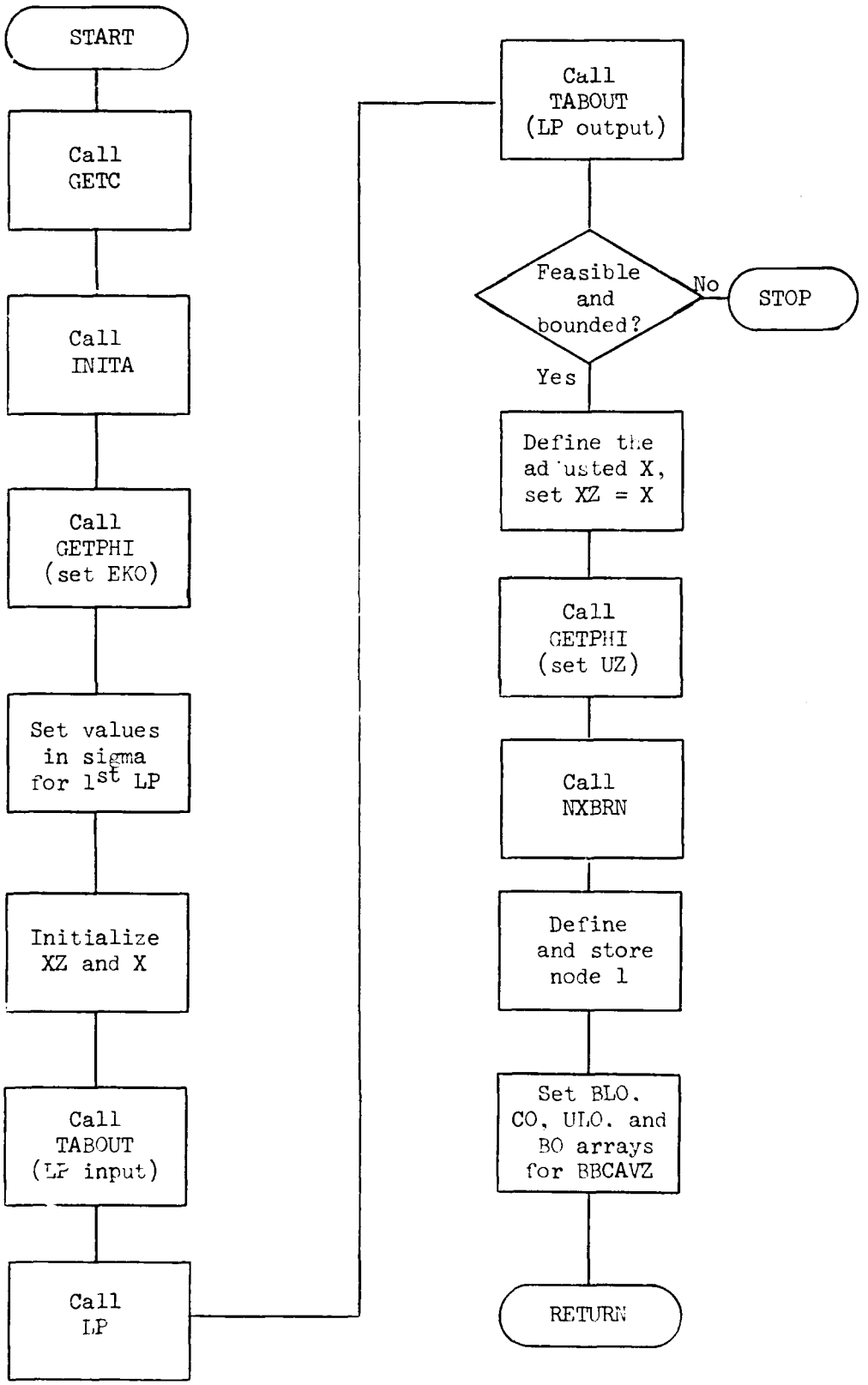


PROGRAM BBCAV2 (con't)

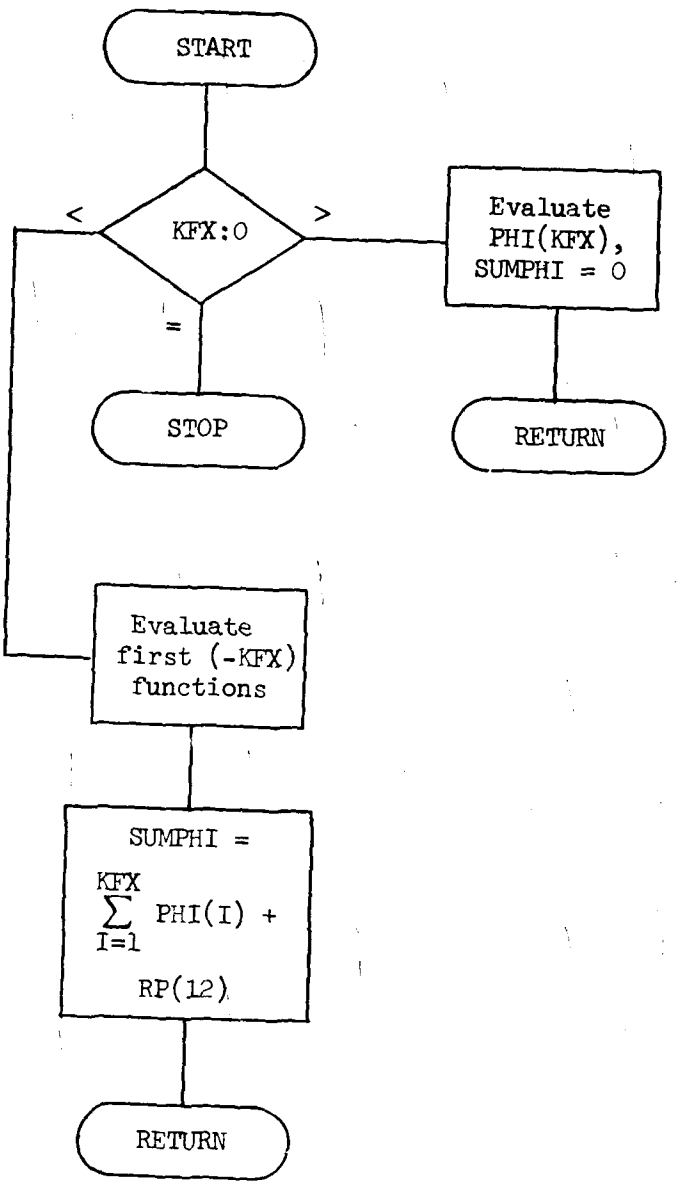



C
Call GETC, update co.
Call TABOUT (LP input)
Call LP
Call TABOUT (LP output)
Feasible and bounded?
A
Define adjusted X-vector
Call GETPHI
PHI ≥ UZ?
Yes
No
Set XZERO equal adj. X and UZ = PHI
Cost2 ≥ US?
Yes
A
Call NXBRN
D

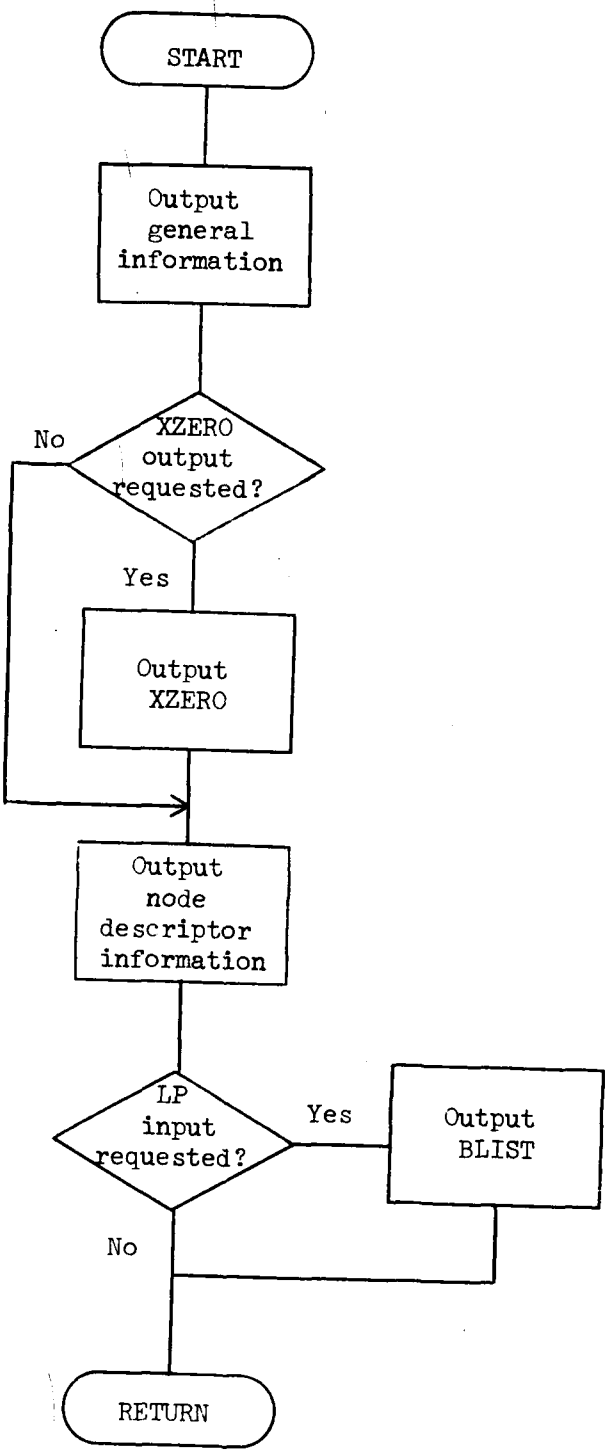
SUBROUTINE BOX1



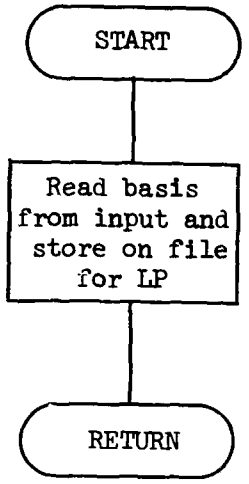
SUBROUTINE GETPHI



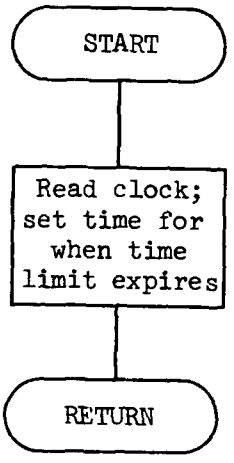
SUBROUTINE TABOUT



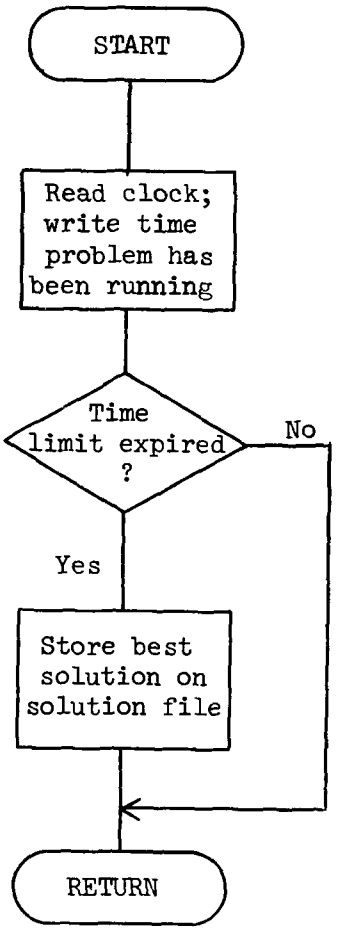
SUBROUTINE READIN



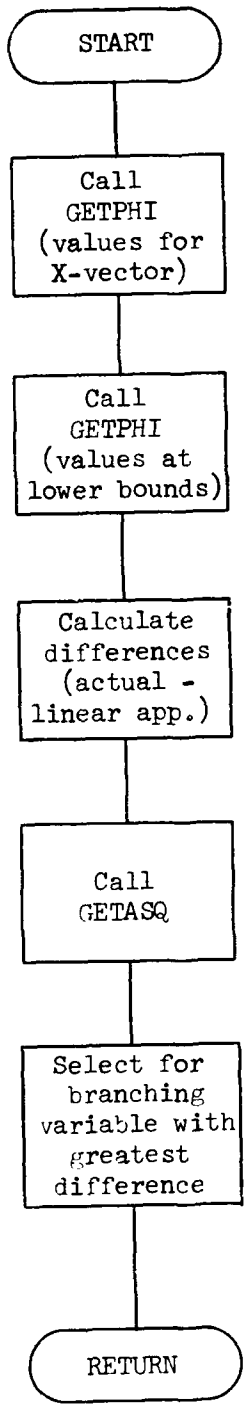
SUBROUTINE SET



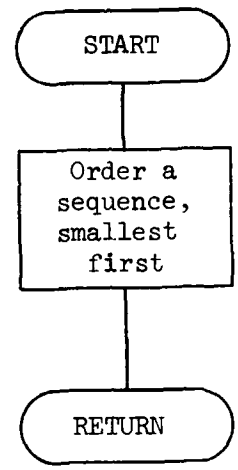
SUBROUTINE TIMEC



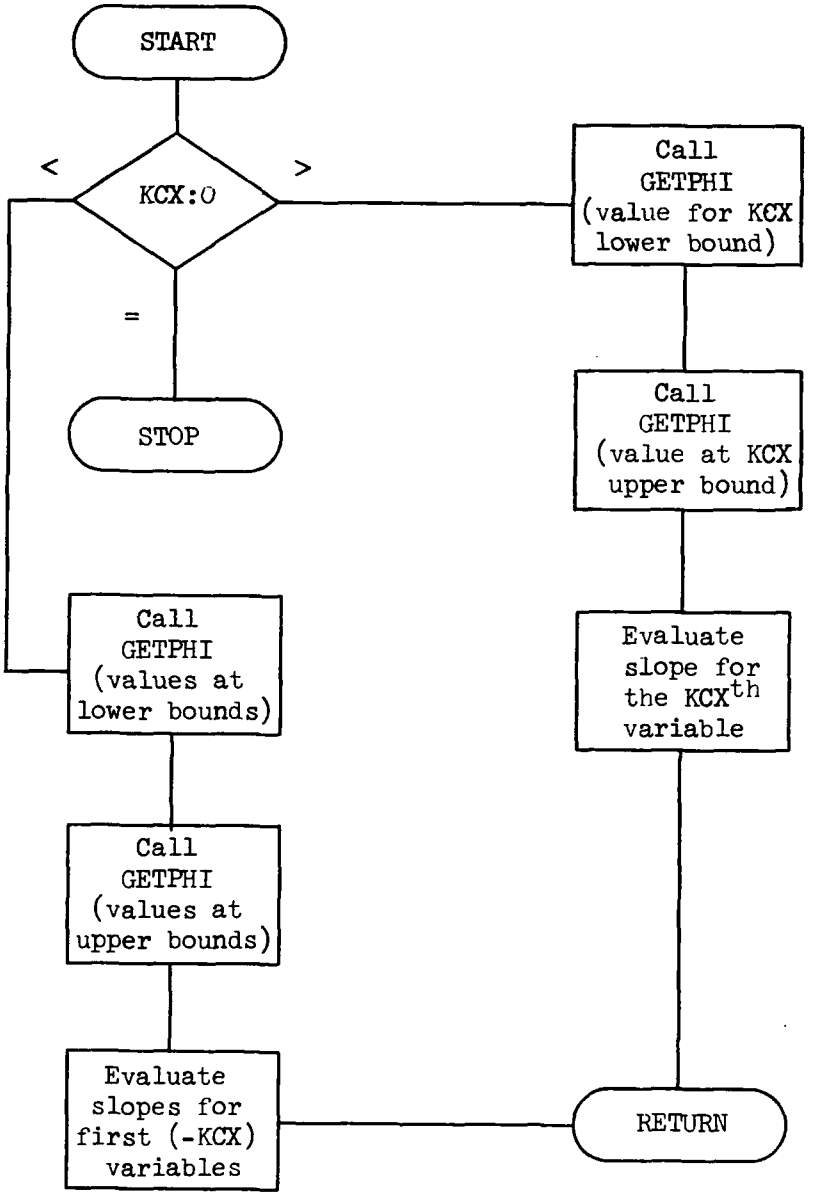
SUBROUTINE NXBRN



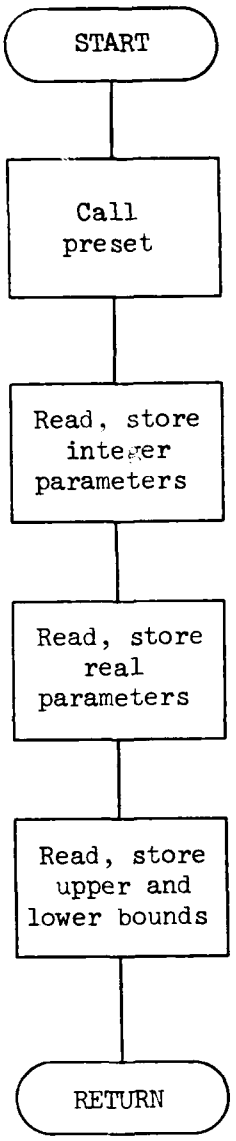
SUBROUTINE GETASQ



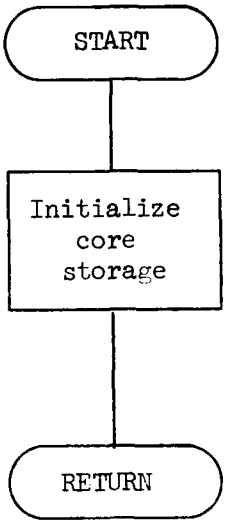
SUBROUTINE GETC



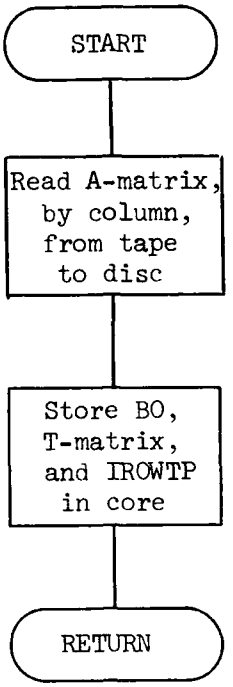
SUBROUTINE PARAMS

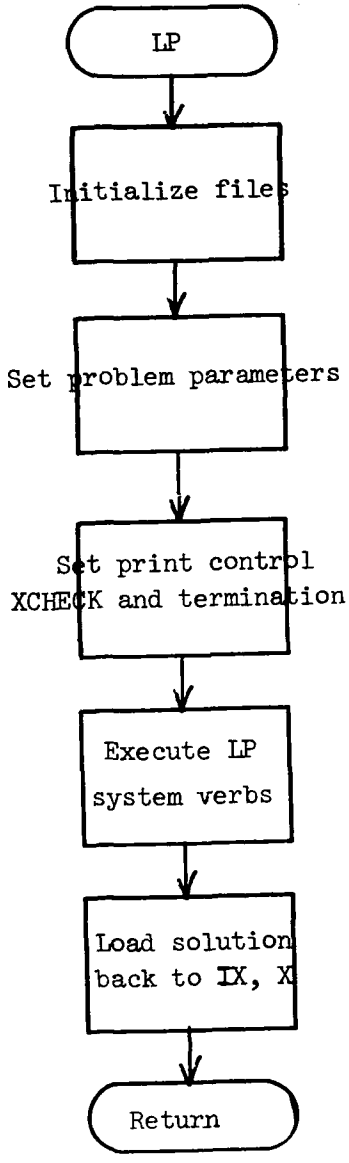


SUBROUTINE PRESET



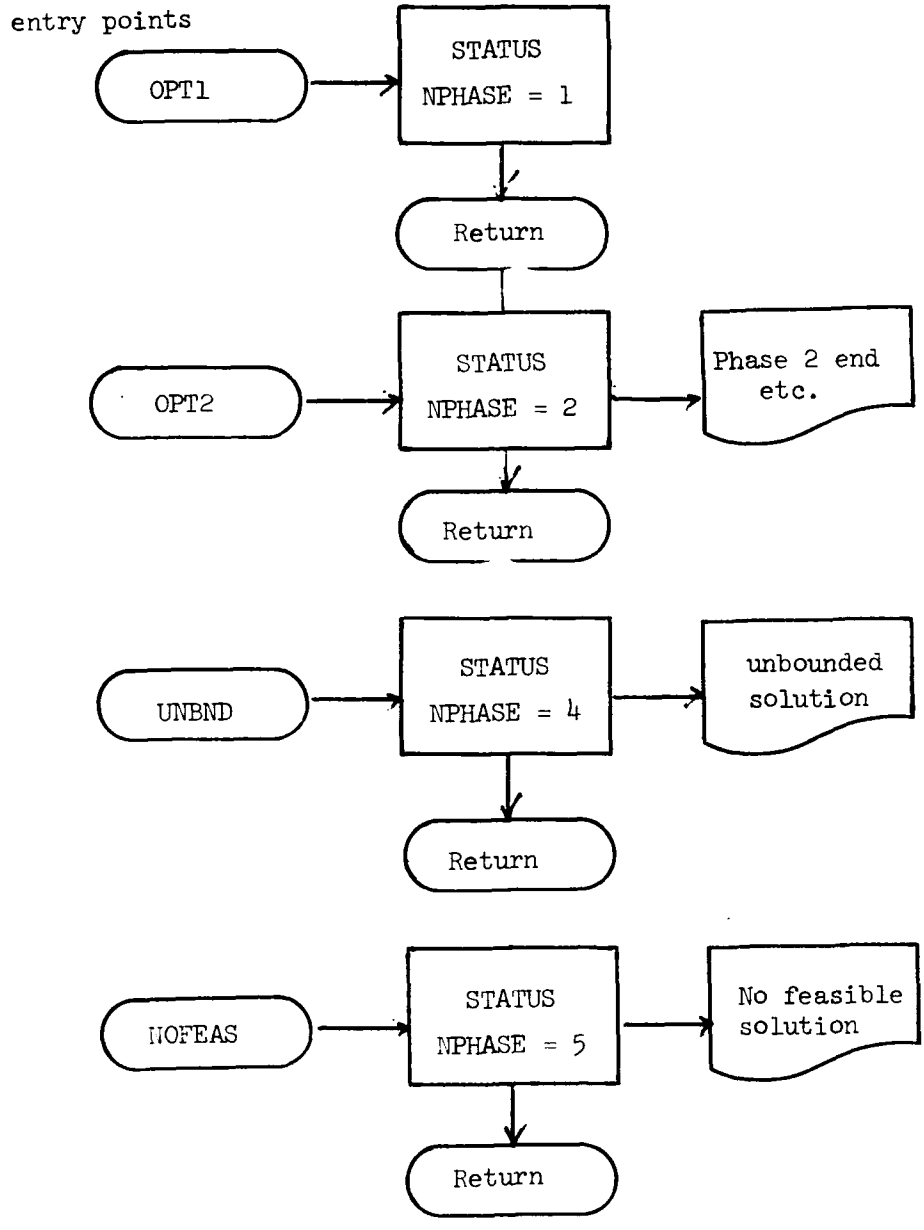
SUBROUTINE INITA




LP
Initialize files
Set problem parameters
Set print control
XCHECK and termination
Execute LP
system verbs
Load solution
back to IX, X
Return

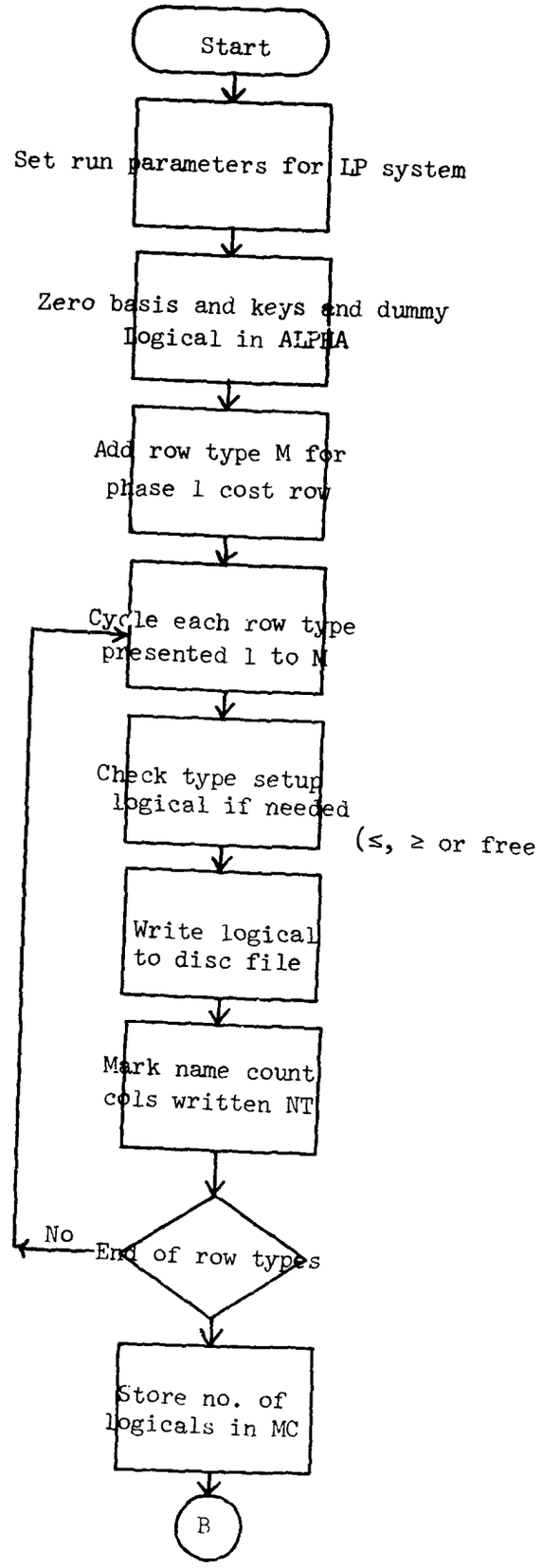
Subroutine EXITS EXITS

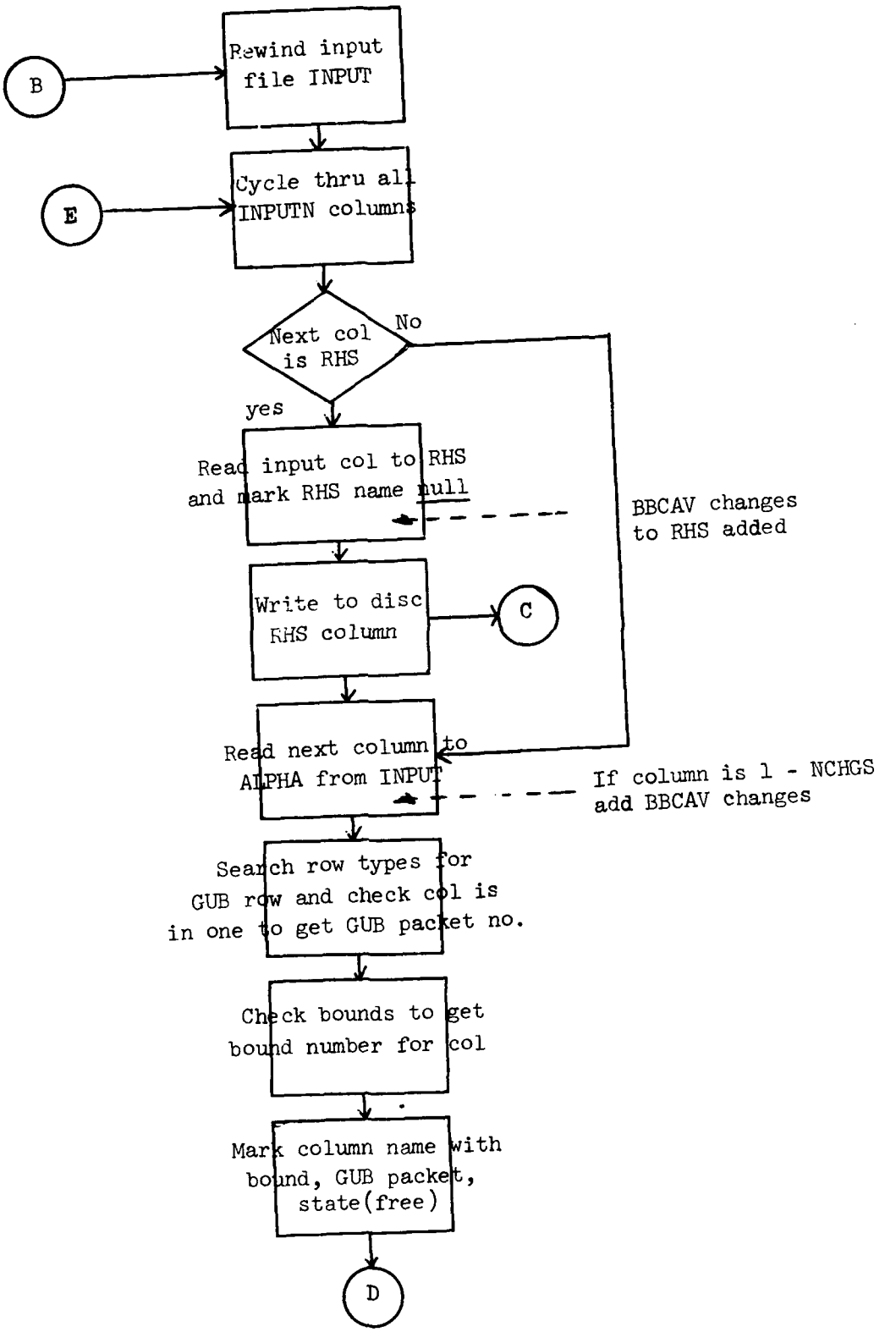
User changable EXITS program called after all control points in PRIMAL.



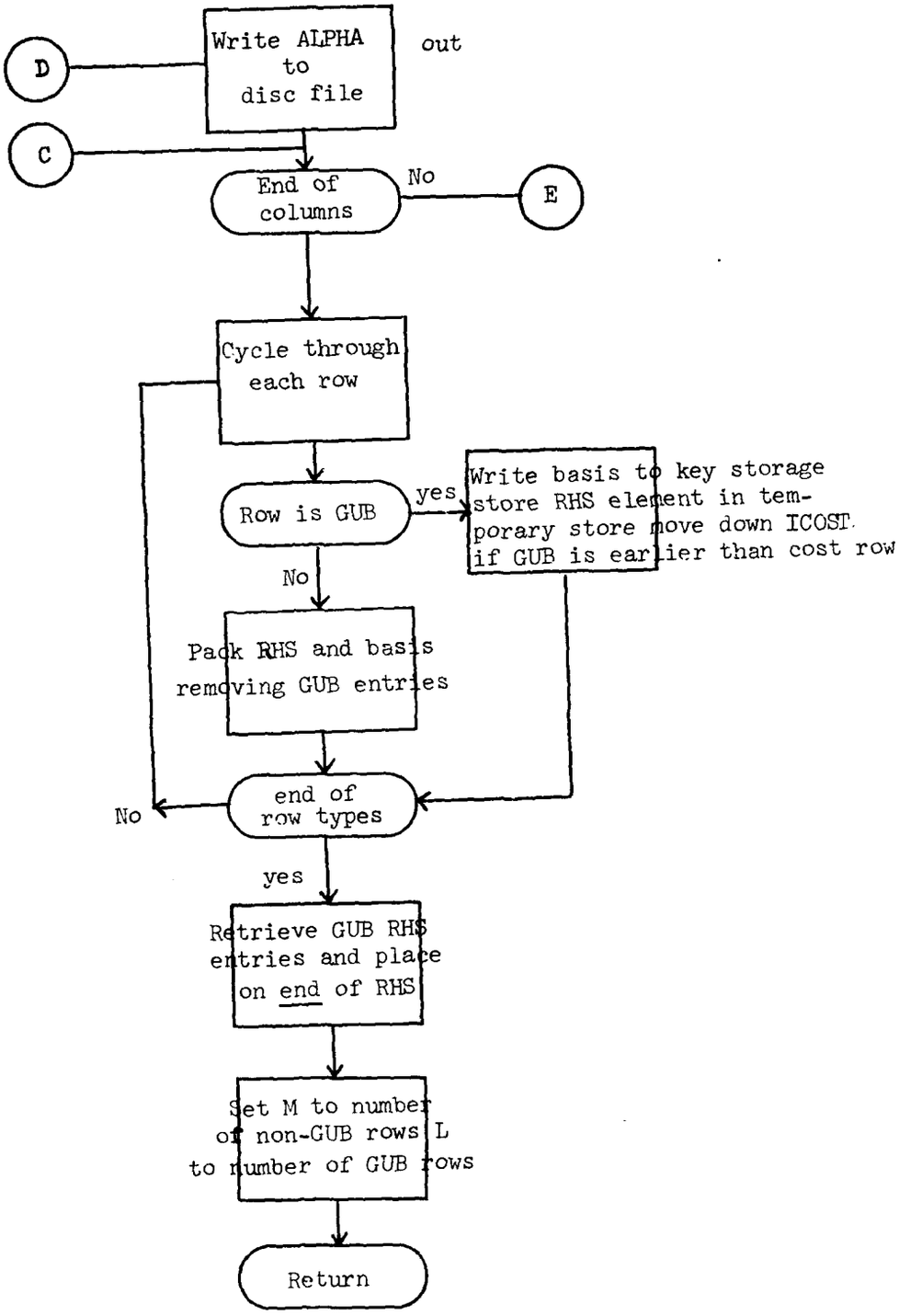
Subroutine SETUP

SETUP 1.



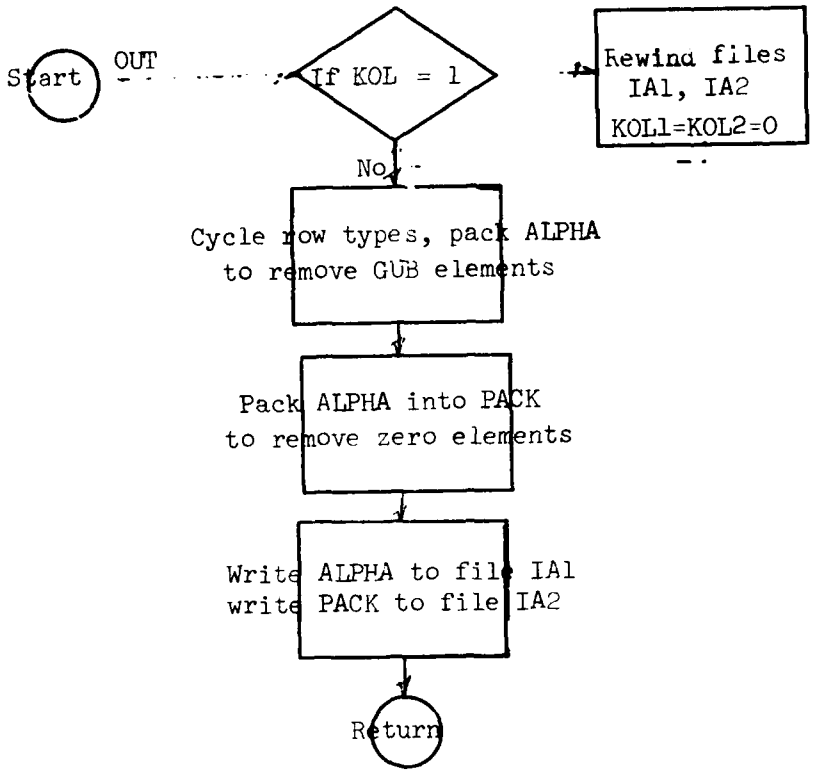

B
Rewind input file INPUT
E
Cycle thru all INPUTN columns
Next col is RHS
No
yes
Read input col to RHS and mark RHS name null
BBCAV changes to RHS added
Write to disc RHS column
C
Read next column to ALPHA from INPUT
If column is 1 - NCHGS add BBCAV changes
Search row types for GUB row and check col is in one to get GUB packet no.
Check bounds to get bound number for col
Mark column name with bound, GUB packet, state(free)
D

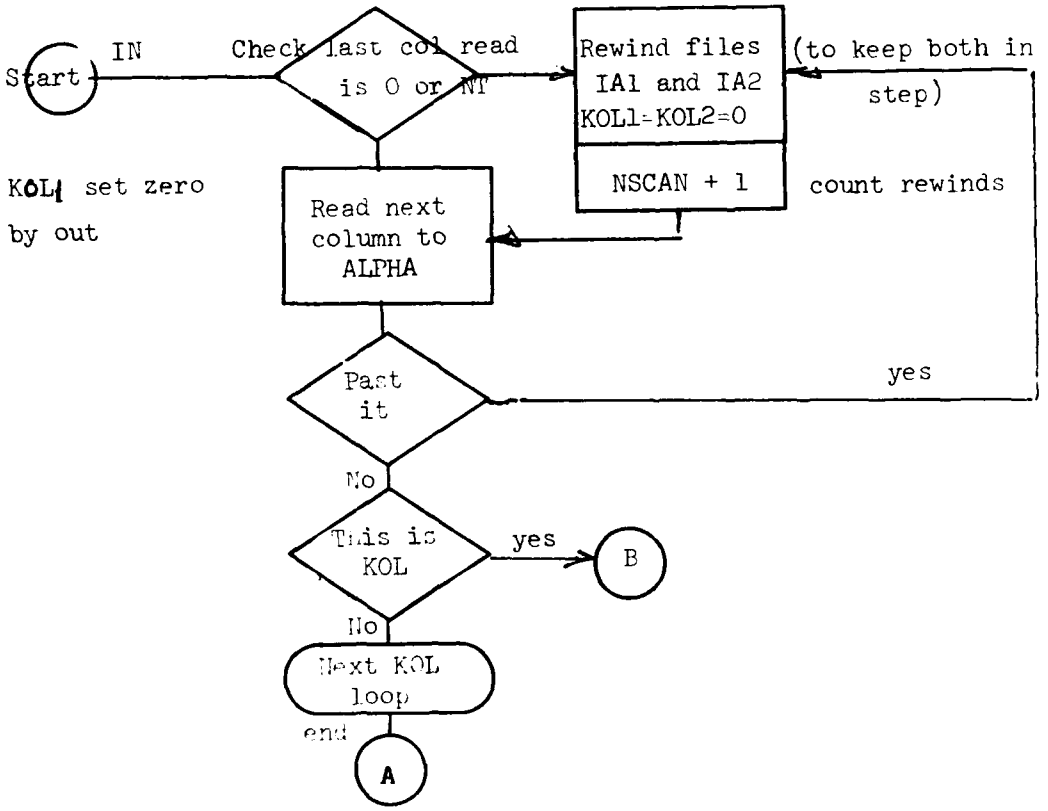
SETUP 3.

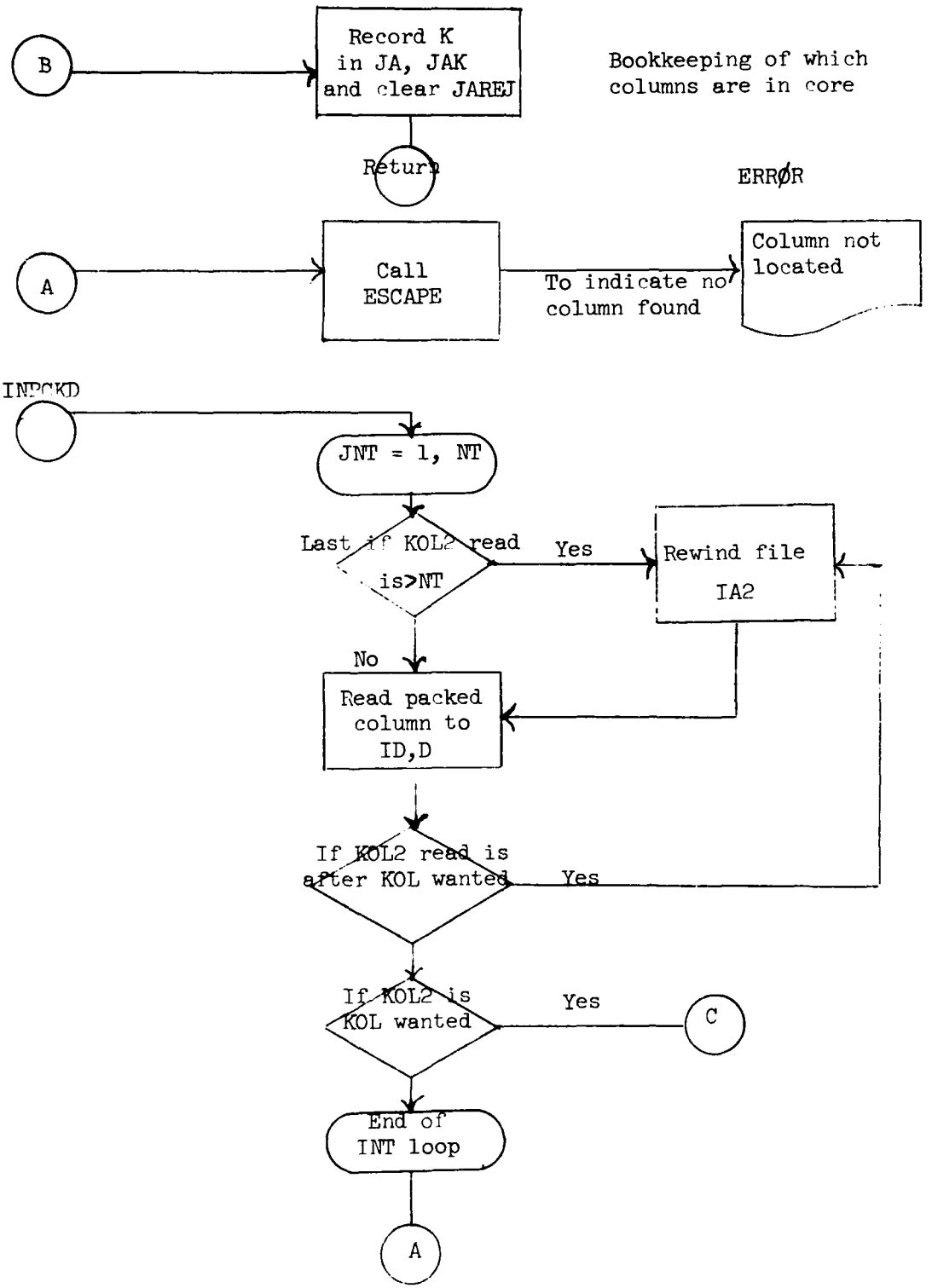

D
Write ALPHA to disc file
out
C
End of columns
No
E
Cycle through each row
Row is GUB
yes
Write basis to key storage store RHS element in temporary store move down ICOST if GUB is earlier than cost row
No
Pack RHS and basis removing GUB entries
end of row types
No
yes
Retrieve GUB RHS entries and place on end of RHS
Set M to number of non-GUB rows L to number of GUB rows
Return

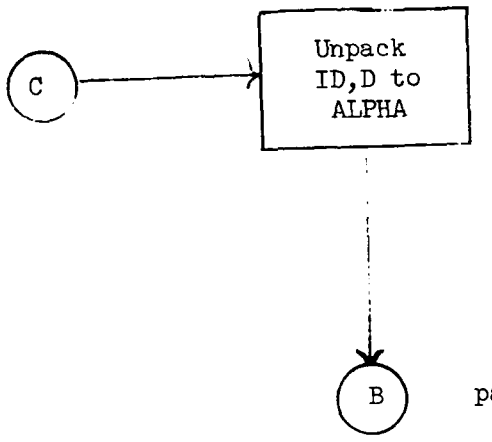
Subroutine IO

IO 1.






B
Record K in JA, JAK and clear JAREJ
Bookkeeping of which columns are in core
Return
ERRØR
A
Call ESCAPE
To indicate no column found
Column not located
INPCKD
JNT = 1, NT
Last if KOL2 read is>NT
Yes
Rewind file IA2
No
Read packed column to ID,D
If KOL2 read is after KOL wanted
Yes
If KOL2 is KOL wanted
Yes
C
End of INT loop
A

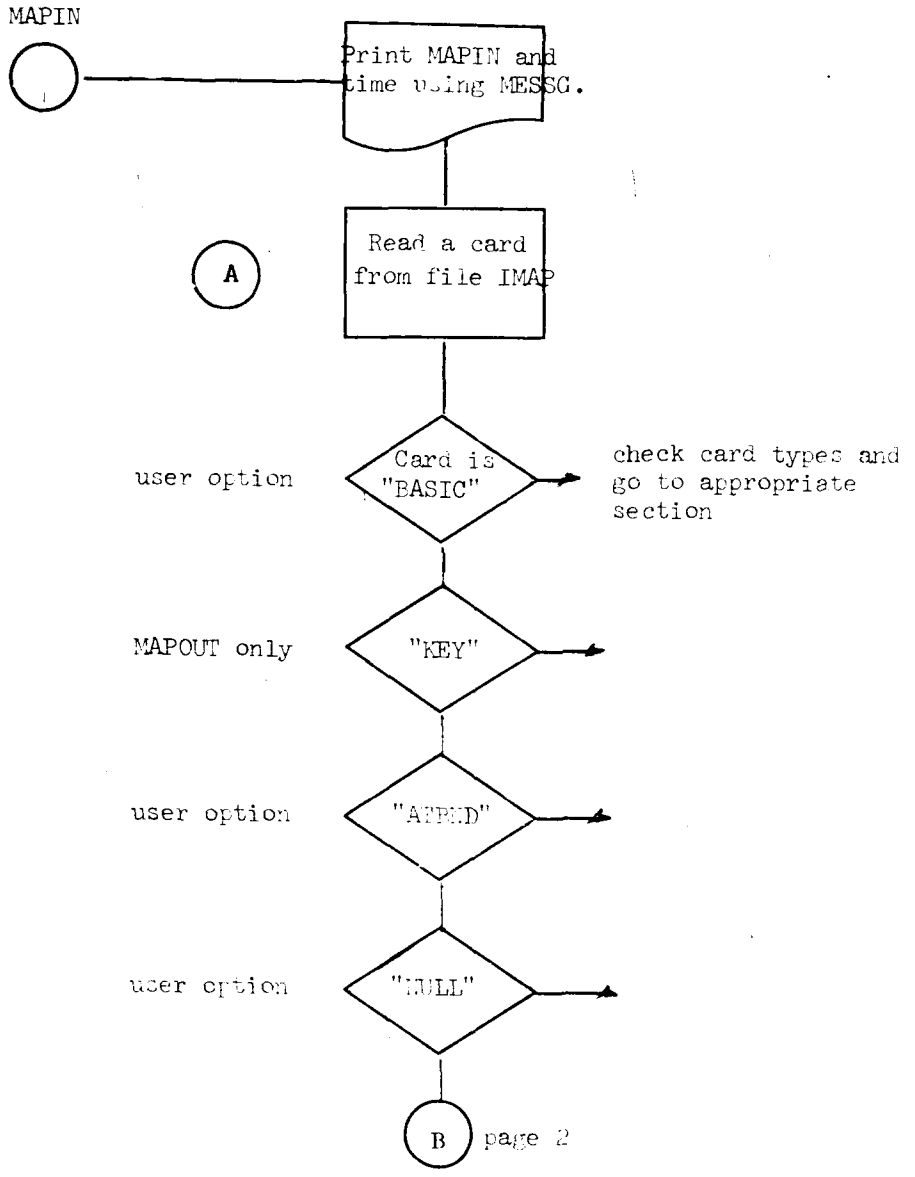


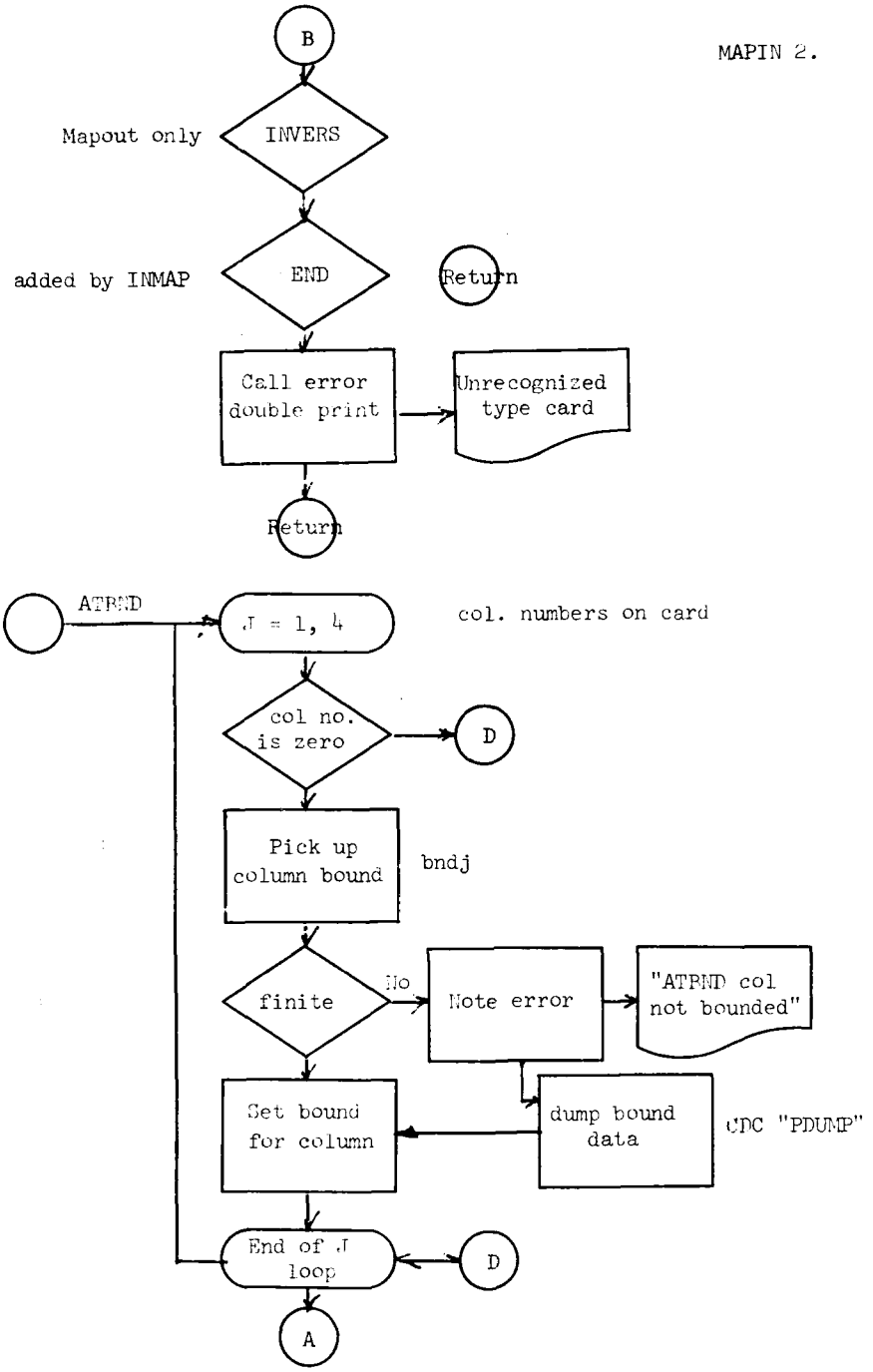
page 2

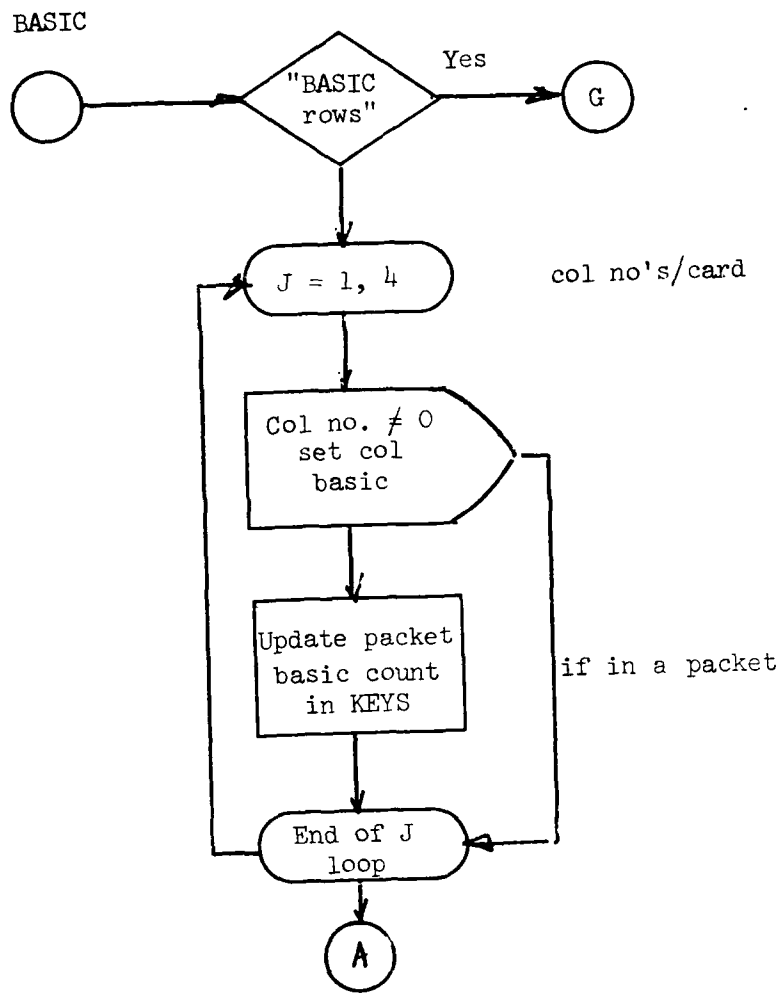
Two entry points

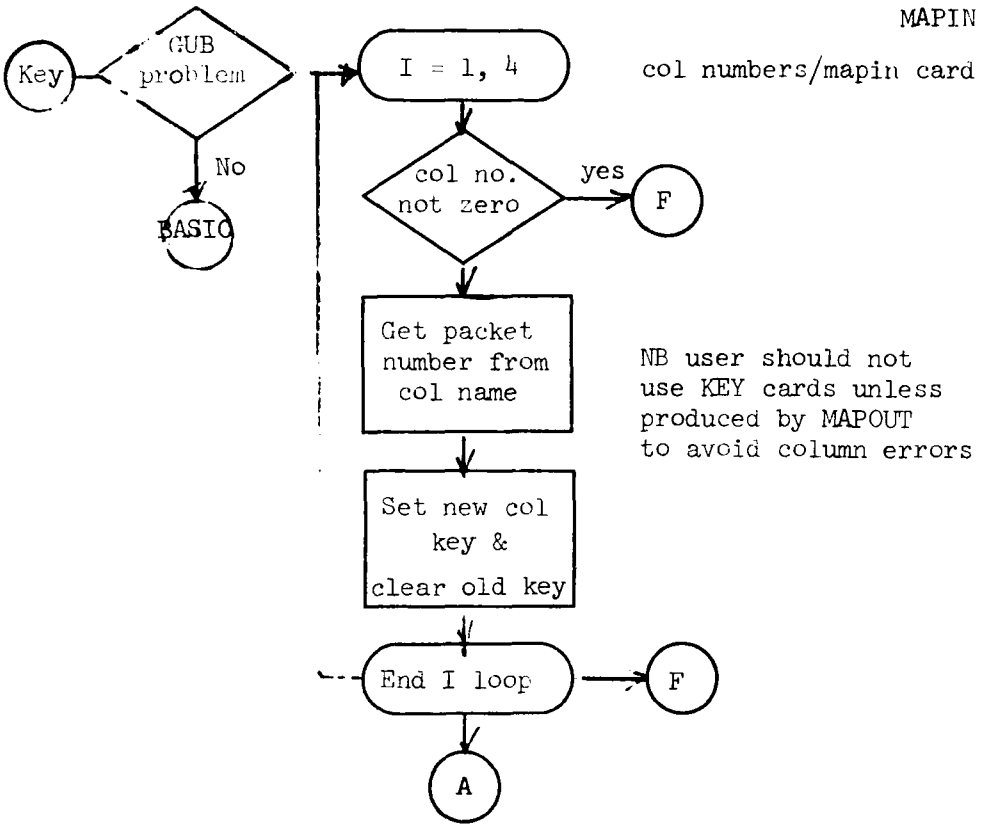
(1) MAPIN - Reads MAPIN cards from file IMAP and sets NAME record reads inverse from file INPUT to B.

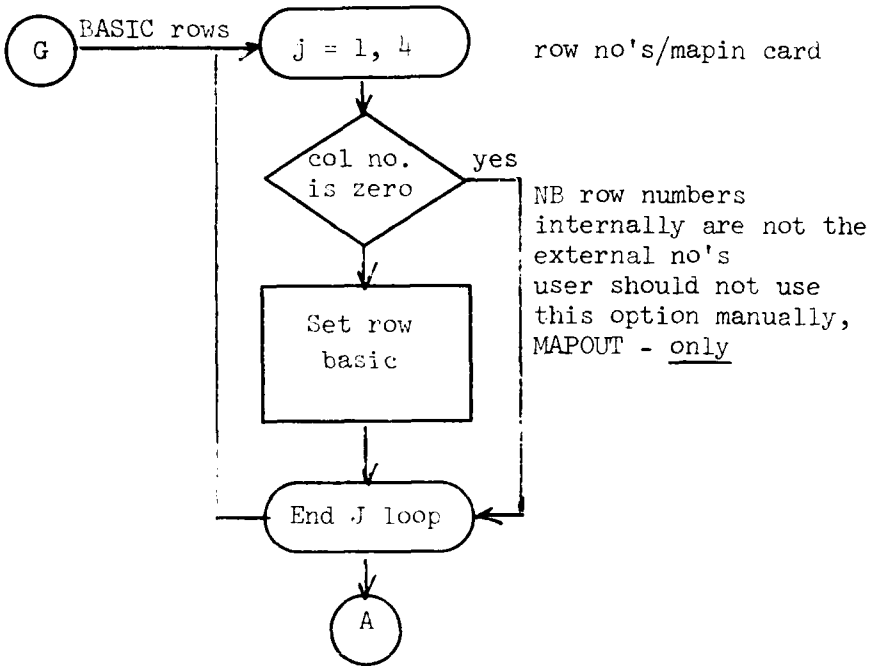
(2) INMAP - Loads file IMAP from input card stream.

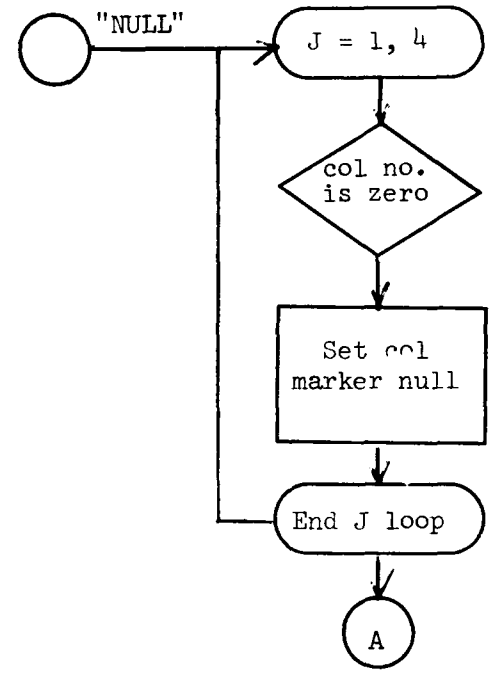



B
Mapout only
INVERS
added by INMAP
END
Return
Call error
double print
Unrecognized
type card
Return
ATRND
J = 1, 4
col. numbers on card
col no.
is zero
D
Pick up
column bound
bndj
finite
No
Note error
"ATRND col
not bounded"
Set bound
for column
dump bound
data
CDC "PDUMP"
End of J
loop
D
A


BASIC
"BASIC rows"
Yes
G
J = 1, 4
col no's/card
Col no. ≠ 0 set col basic
Update packet basic count in KEYS
if in a packet
End of J loop
A

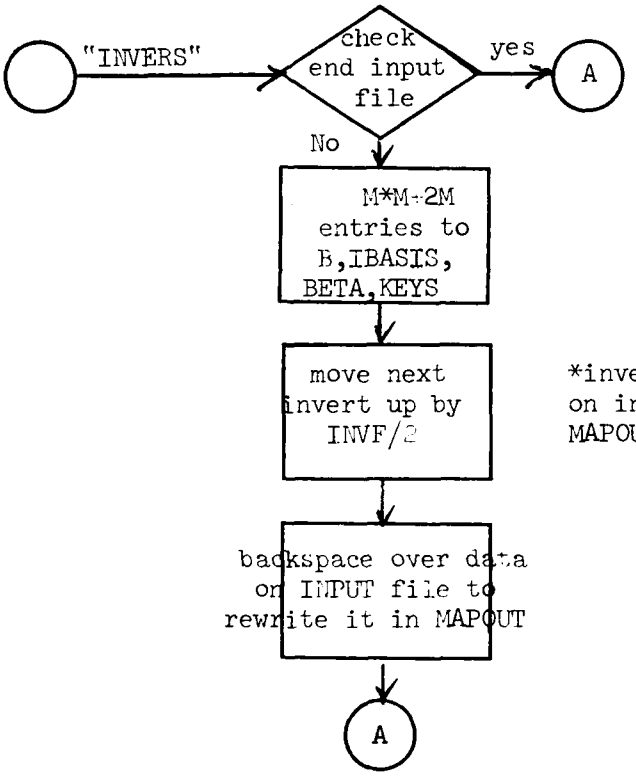

Key
GUB problem
No
BASIC
I = 1, 4
col numbers/mapin card
col no. not zero
yes
F
Get packet number from col name
NB user should not use KEY cards unless produced by MAPOUT to avoid column errors
Set new col key &
clear old key
End I loop
F
A


G
BASIC rows
j = 1, 4
row no's/mapin card
col no. is zero
yes
NB row numbers internally are not the external no's user should not use this option manually, MAPOUT - only
Set row basic
End J loop
A

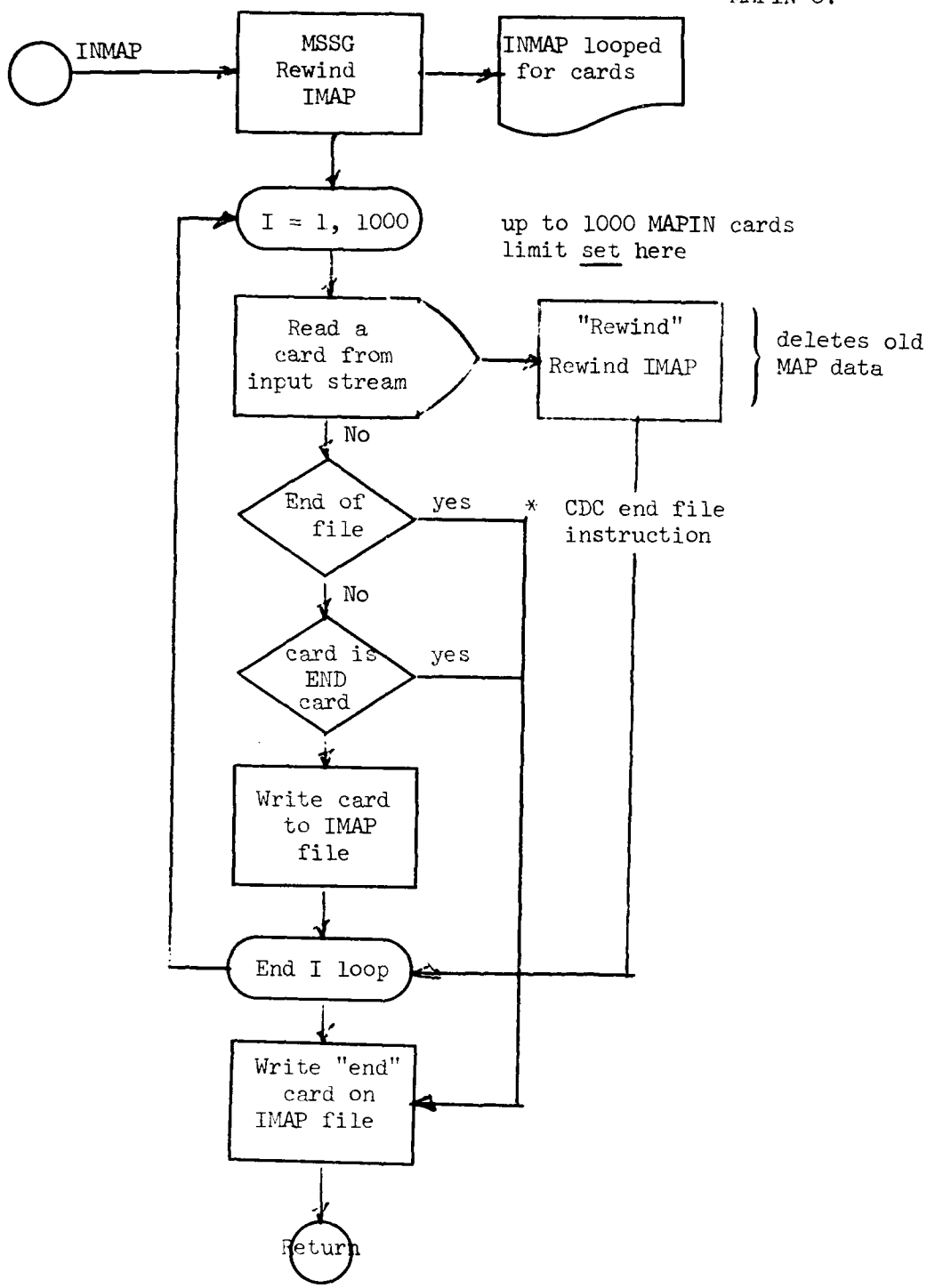


col no's/mapin card

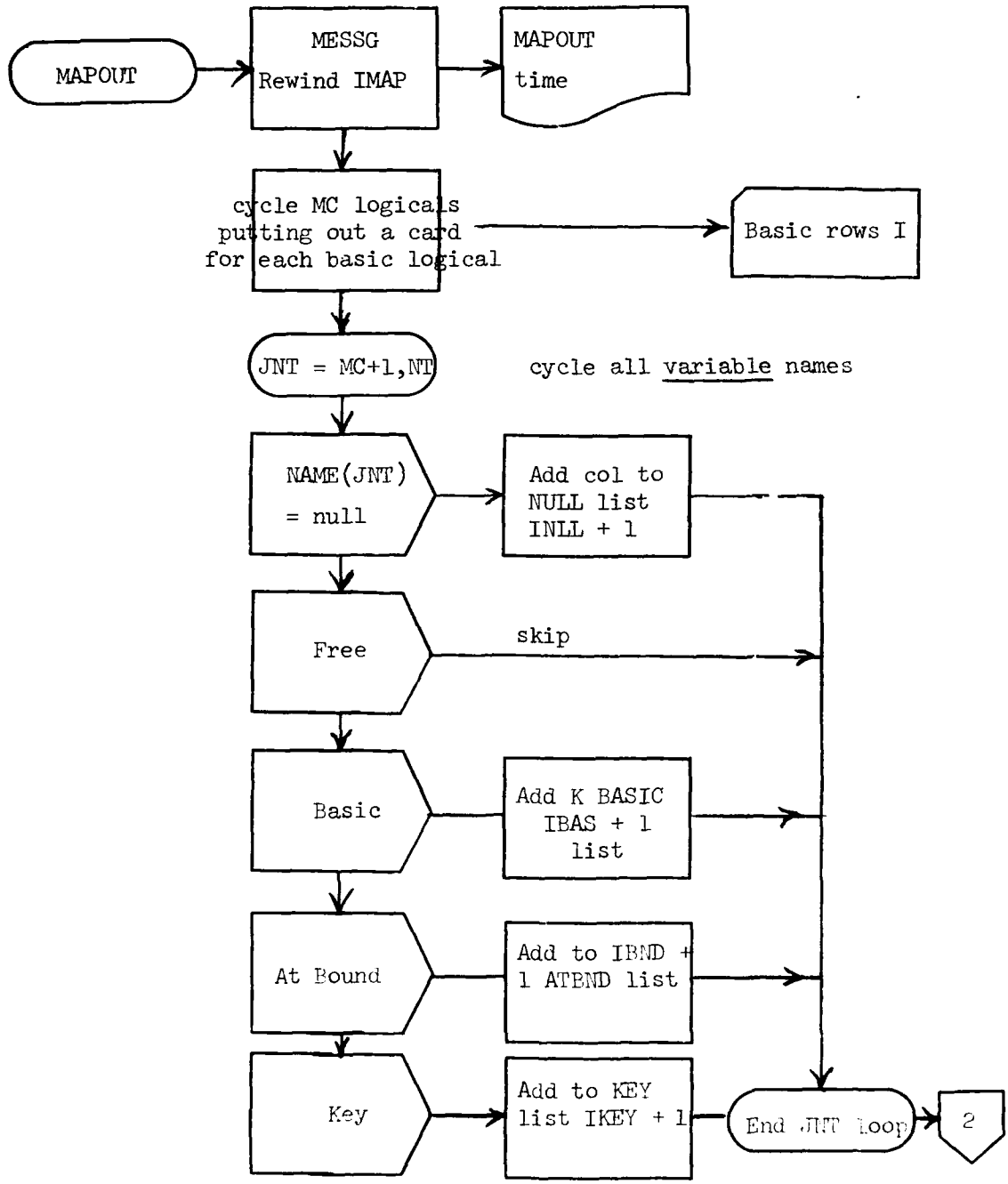
user option

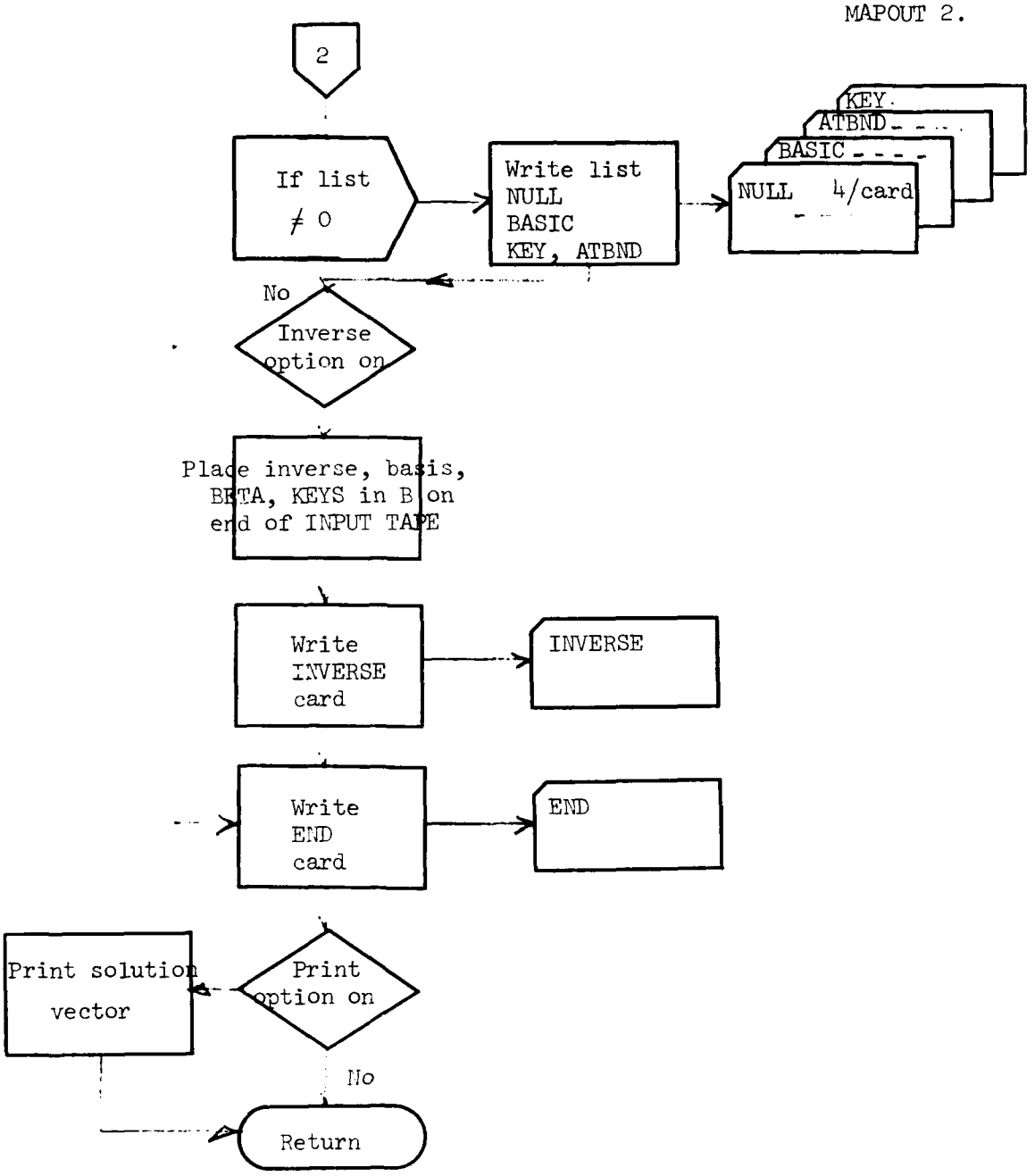


*inverse by rows placed on input file by MAPOUT

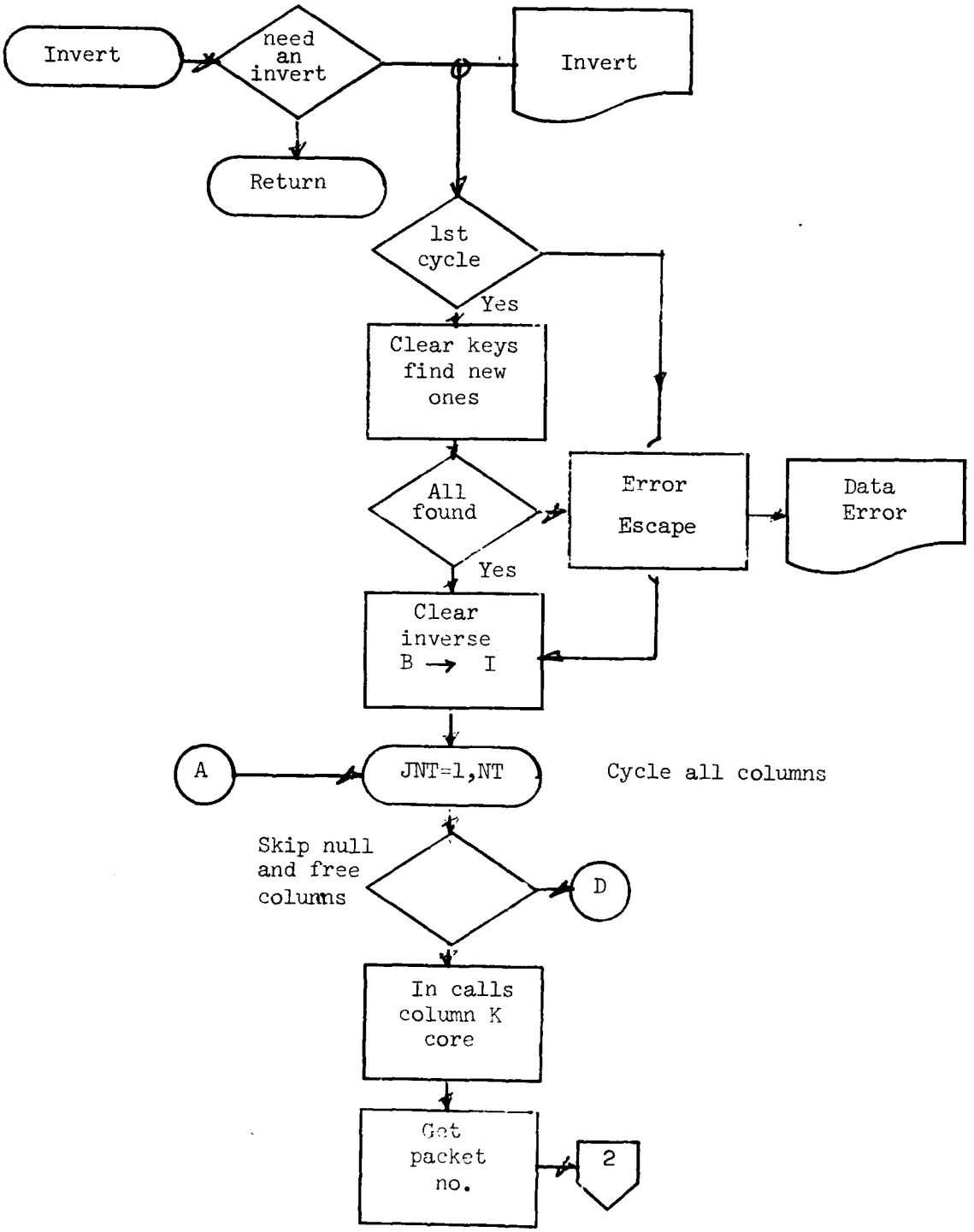

INMAP
MSSG
Rewind
IMAP
INMAP looped
for cards
I = 1, 1000
up to 1000 MAPIN cards
limit set here
Read a
card from
input stream
"Rewind"
Rewind IMAP
deletes old
MAP data
No
End of
file
yes
*
CDC end file
instruction
No
card is
END
card
yes
Write card
to IMAP
file
End I loop
Write "end"
card on
IMAP file
Return

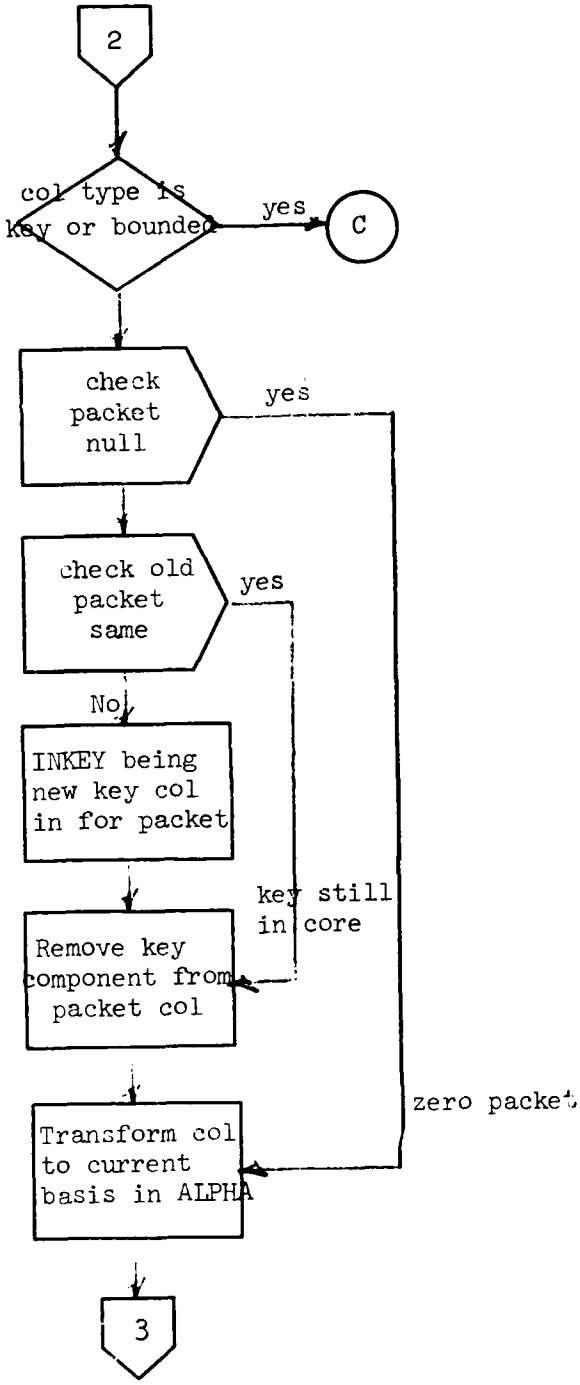
MAPOUT outputs on file IMAP a BCD card image definition of variables and inverse states compatible with MAPIN, whenever called and prints the current solution.

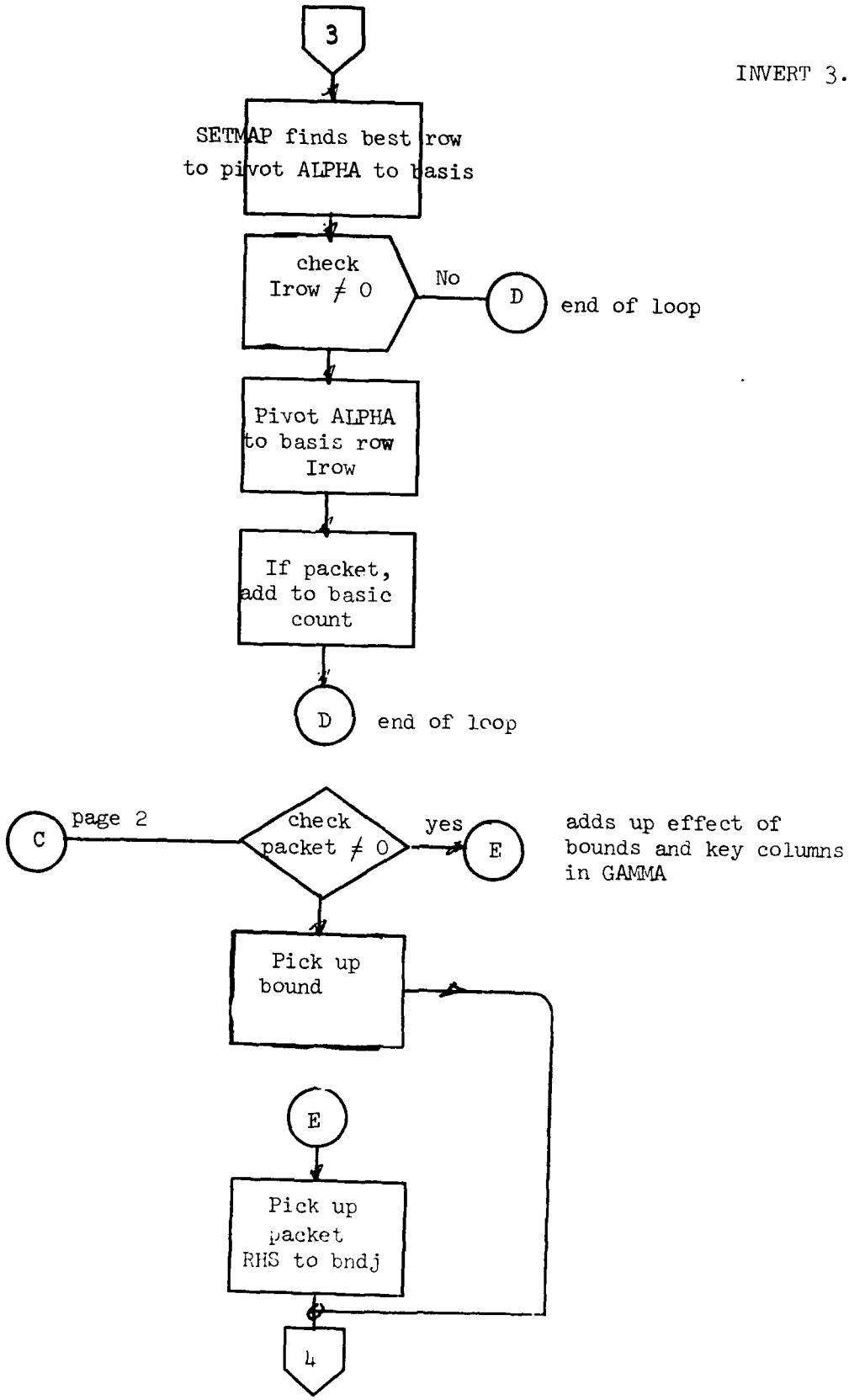


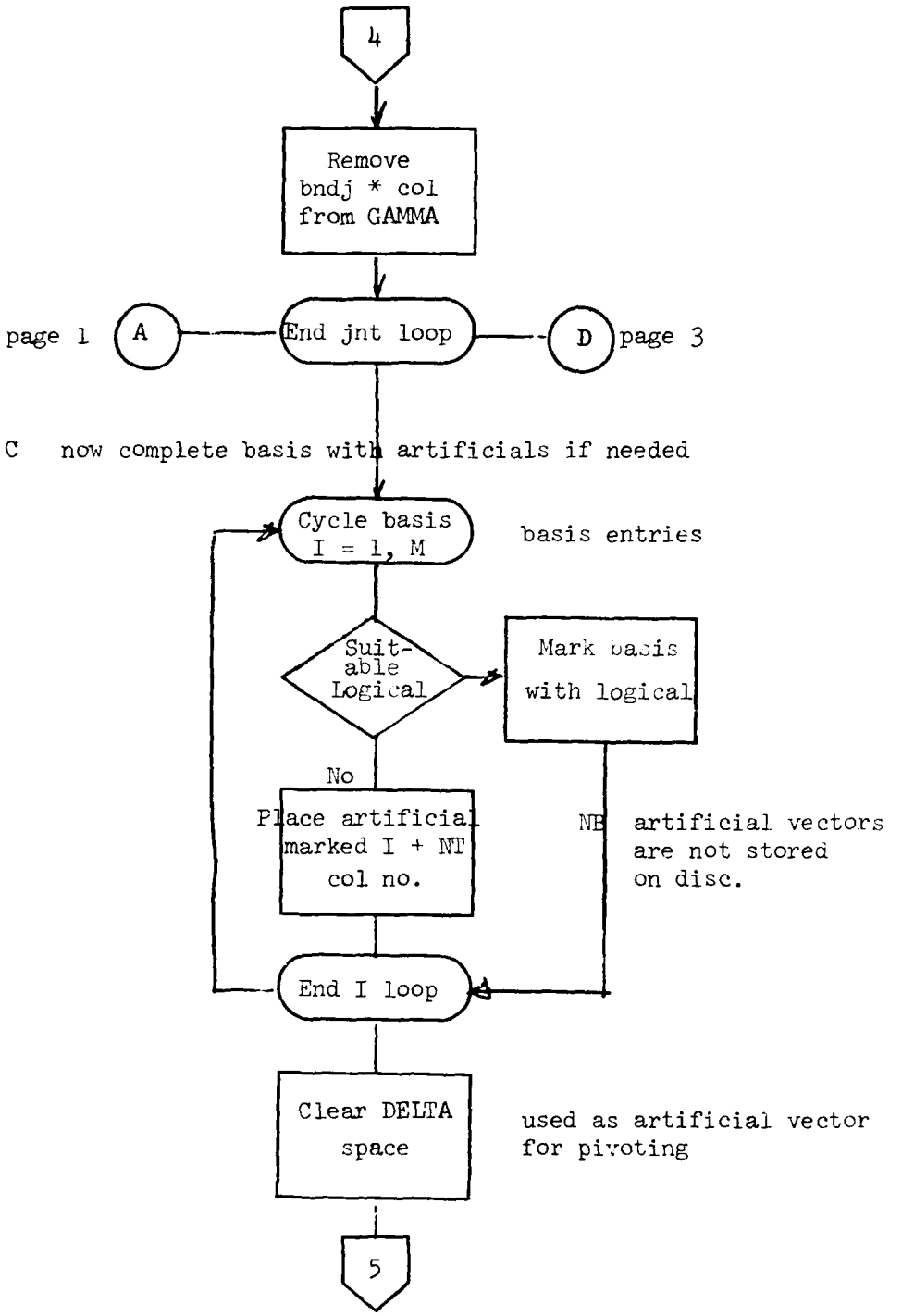


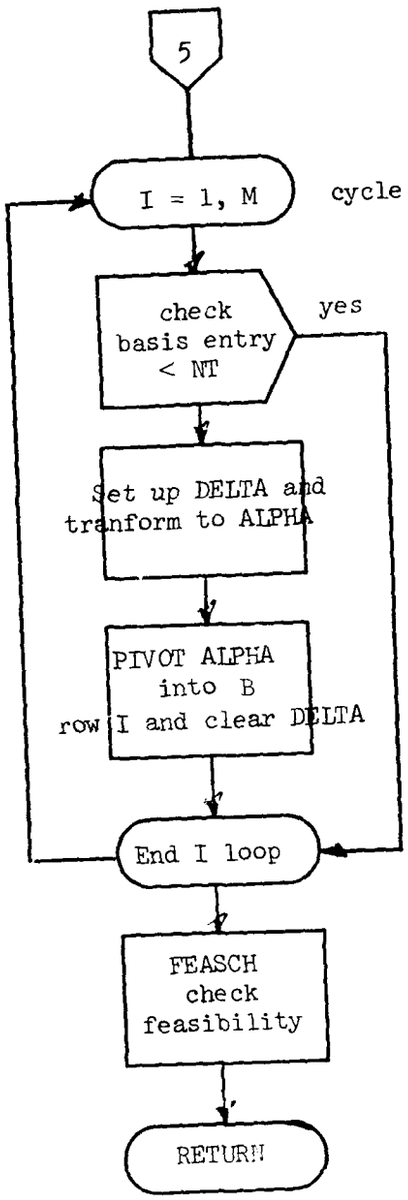
N.B. All MAPOUT cards can be generated manually. If they are inconsistant MAPIN uses the last setting of any column.


Invert
need an invert
Invert
Return
lst cycle
Yes
Clear keys find new ones
All found
Error Escape
Data Error
Yes
Clear inverse B → I
A
JNT=1,NT
Cycle all columns
Skip null and free columns
D
In calls column K core
Get packet no.
2


2
col type is key or bounded
yes
C
check packet null
yes
check old packet same
yes
No
INKEY being new key col in for packet
key still in core
Remove key component from packet col
zero packet
Transform col to current basis in ALPHA
3

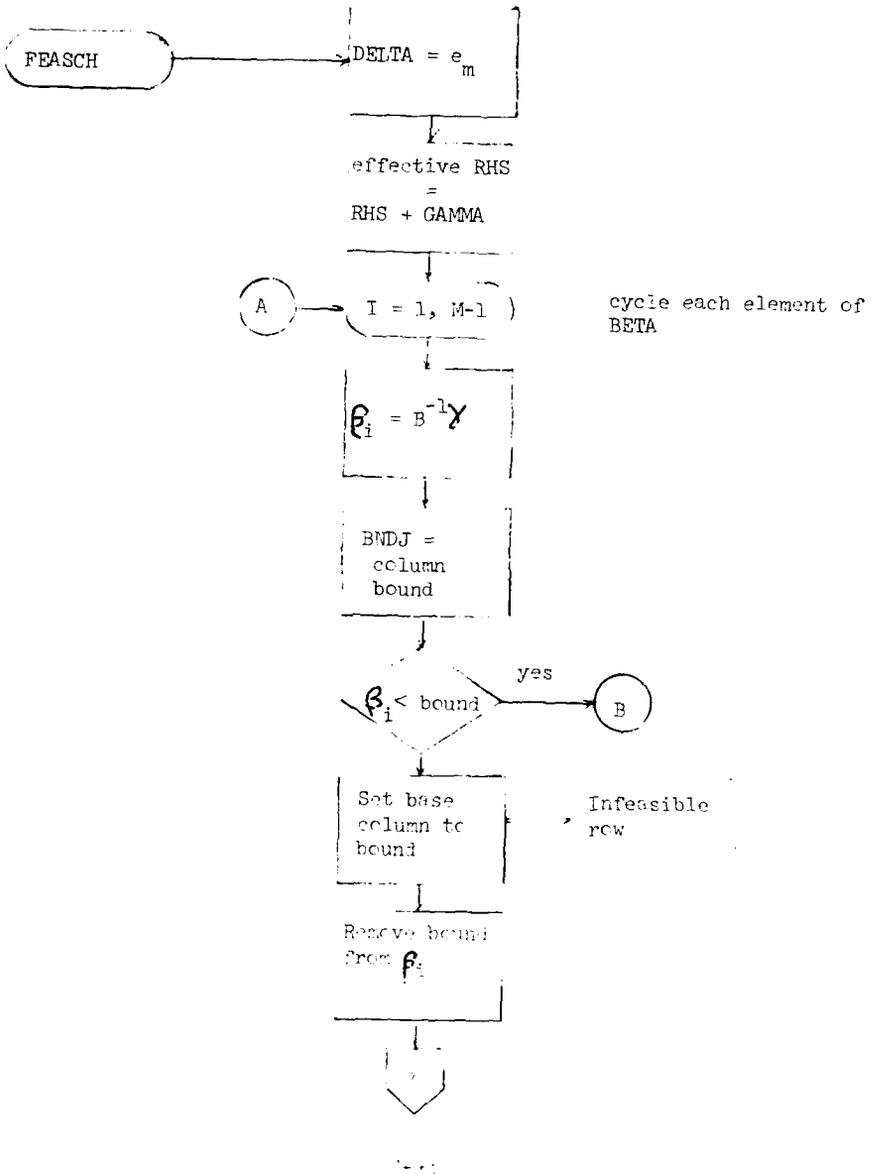

3
SETMAP finds best row to pivot ALPHA to basis
check Irow ≠ 0
No
D
end of loop
Pivot ALPHA to basis row Irow
If packet, add to basic count
D
end of loop
C
page 2
check packet ≠ 0
yes
E
adds up effect of bounds and key columns in GAMMA
Pick up bound
E
Pick up packet RHS to bndj
4

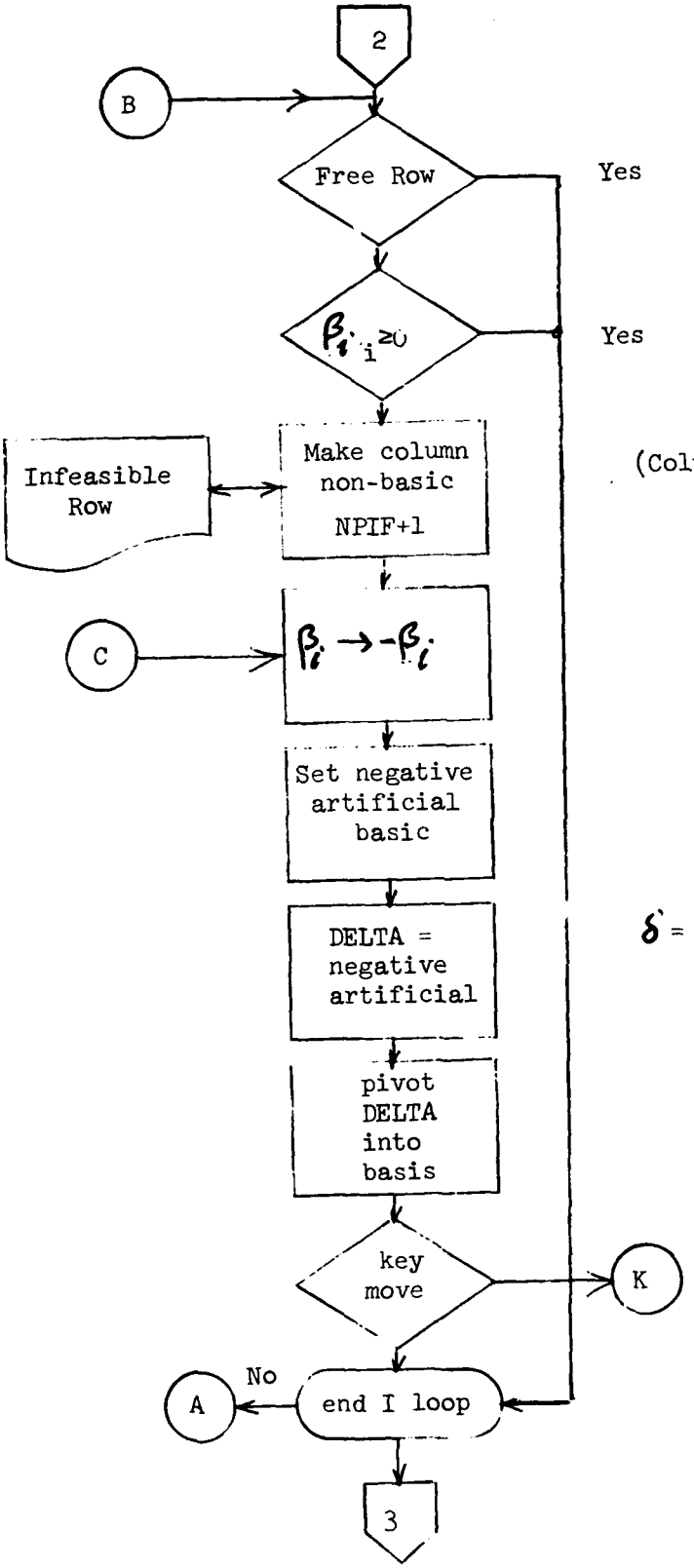

4
Remove bndj * col from GAMMA
page 1
A
End jnt loop
D
page 3
C now complete basis with artificials if needed
Cycle basis I = 1, M
basis entries
Suit-able Logical
Mark basis with logical
No
Place artificial marked I + NT col no.
NB artificial vectors are not stored on disc.
End I loop
Clear DELTA space
used as artificial vector for pivoting
5


5
I = 1, M
cycle basis entries
check basis entry < NT
yes
Set up DELTA and tranform to ALPHA
pivot artificials in when necessary
PIVOT ALPHA into B row I and clear DELTA
End I loop
FEASCH check feasibility
RETURN

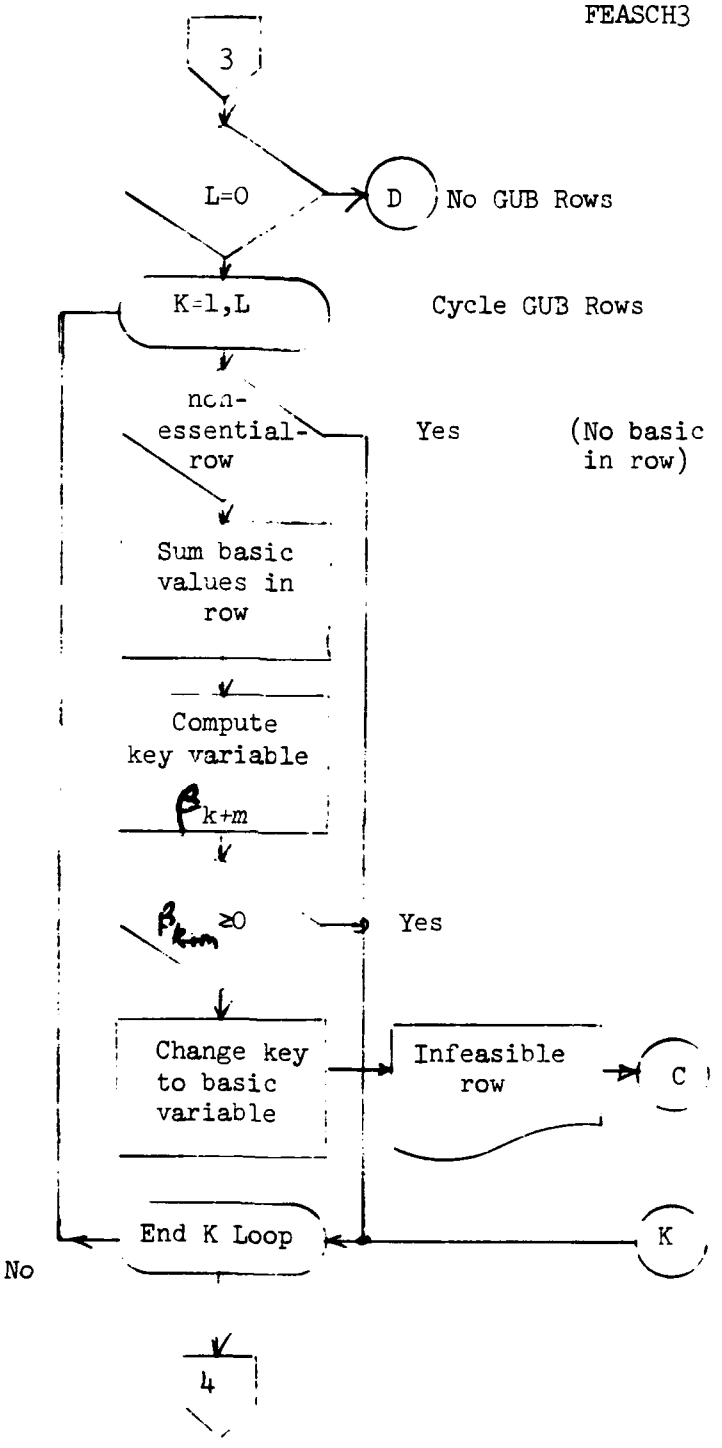
Subroutine FEASCH

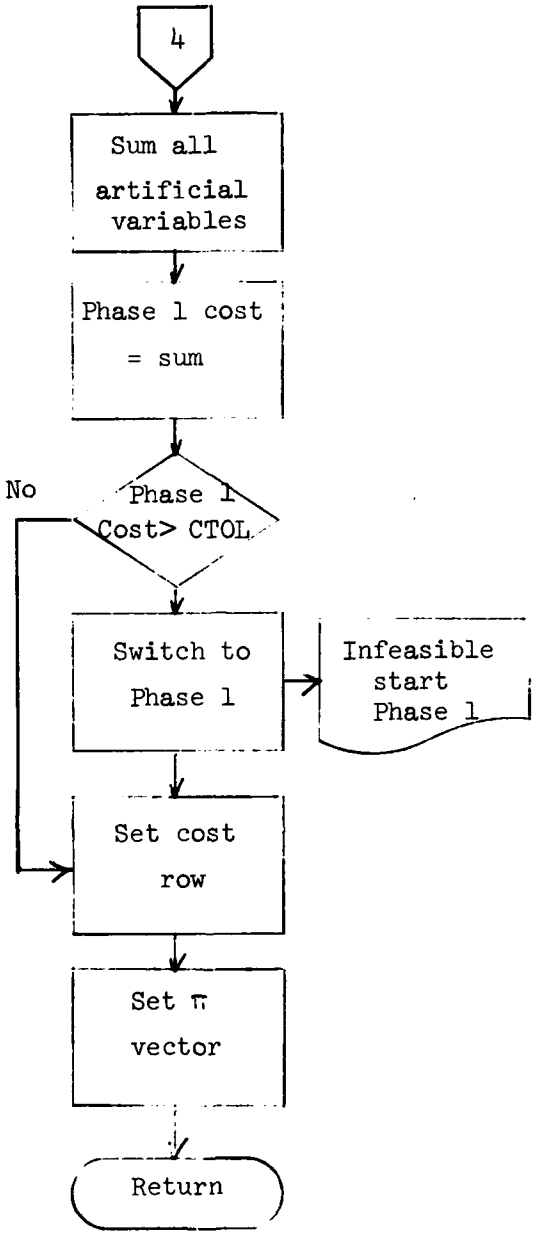
This routine computes the solution and checks feasibility.



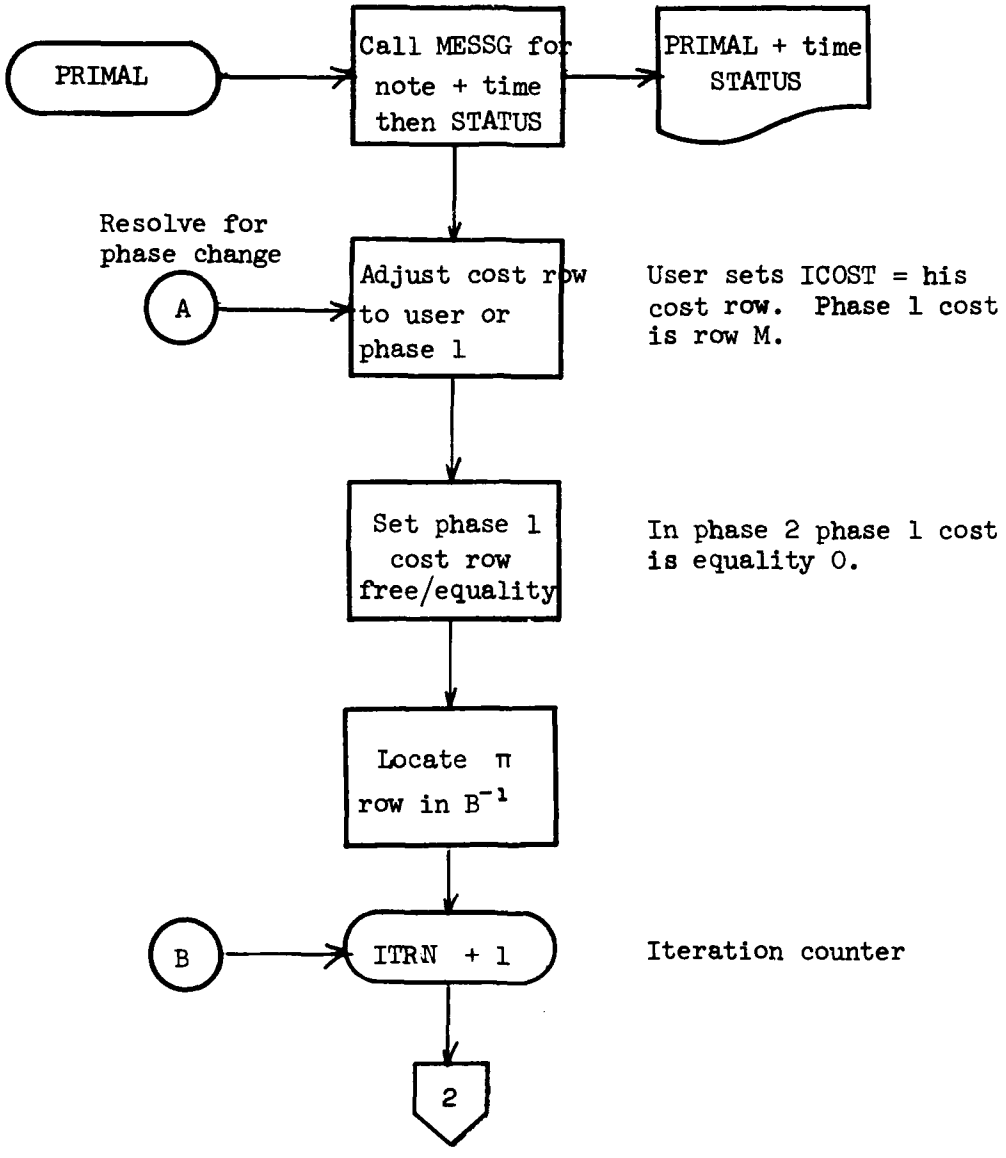

2
B
Free Row
Yes
β_i i ≥0
Yes
Infeasible Row
Make column non-basic
NPIF+1
(Column basic in Row I)
C
$\beta_i \rightarrow -\beta_i$
Set negative artificial basic
DELTA = negative artificial
$\delta = -A_j + e_m$
pivot DELTA into basis
key move
K
Return to check feasibility of keys.
No
A
end I loop
3

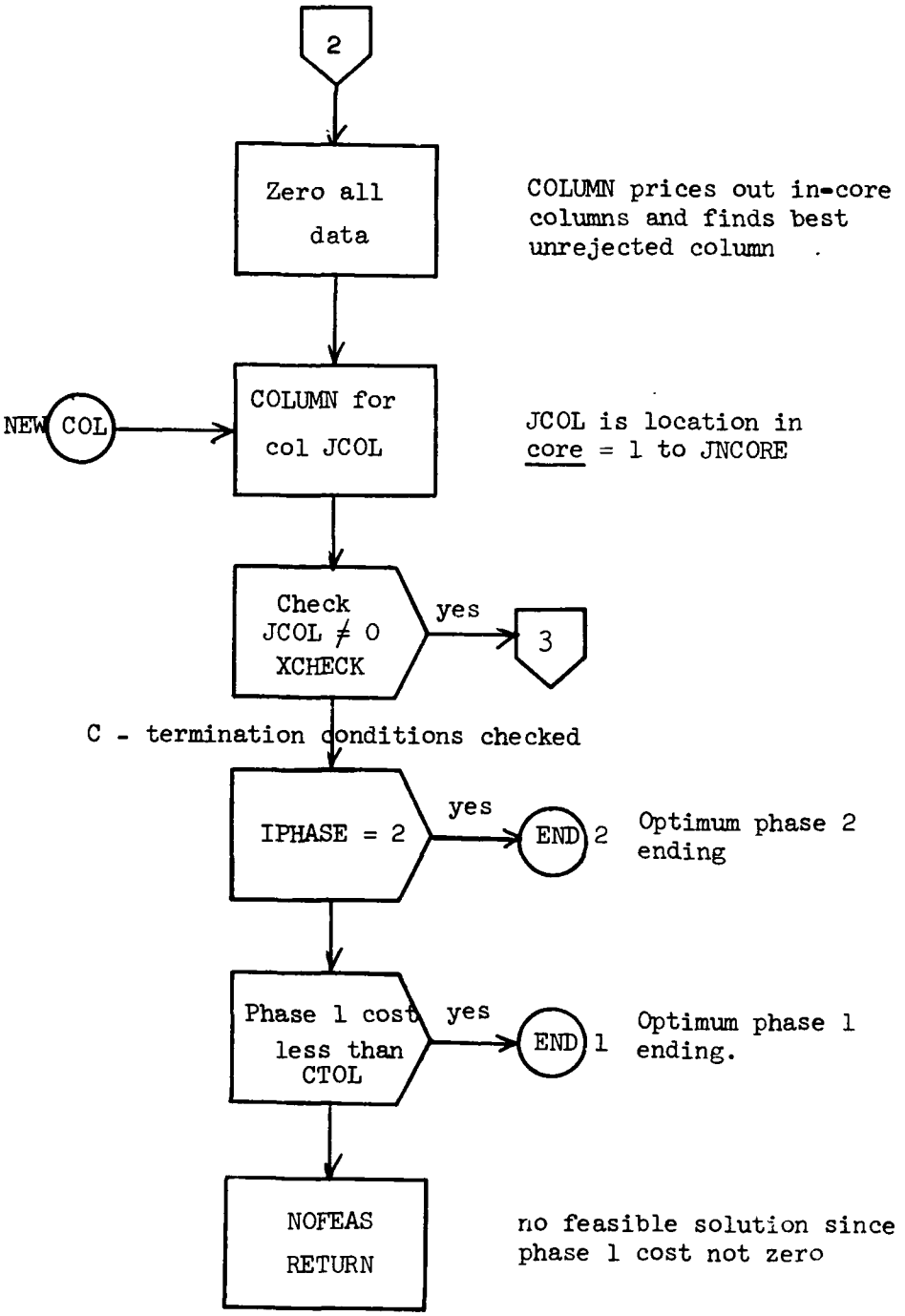
FEASCH3

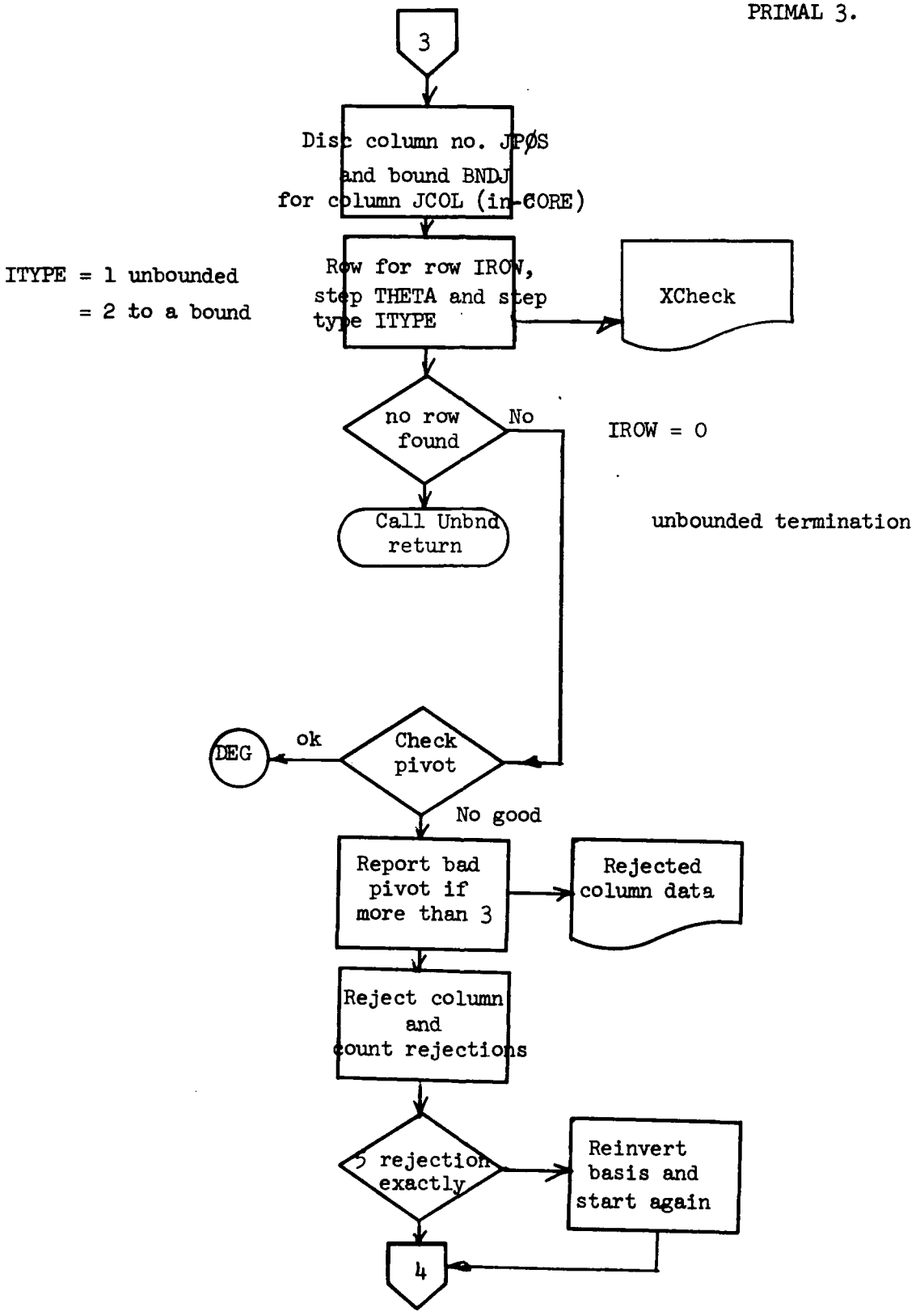

3
L=0
D
No GUB Rows
K=1,L
Cycle GUB Rows
non-essential-row
Yes
(No basic columns in row)
Sum basic values in row
Compute key variable
β_{k+m}
$\beta_{km} \geq 0$
Yes
Change key to basic variable
Infeasible row
C
End K Loop
K
No
4

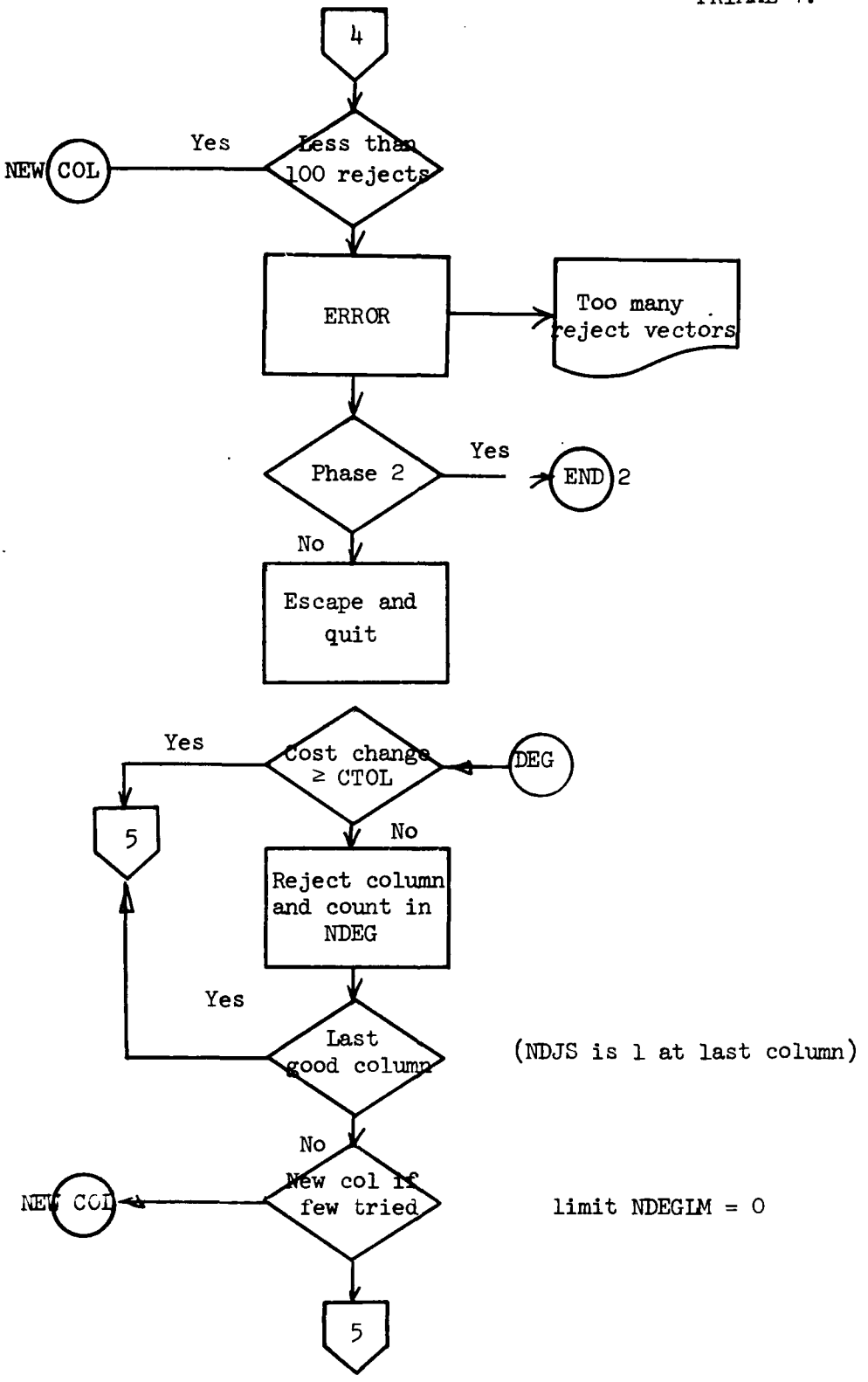

4
Sum all artificial variables
Phase 1 cost = sum
No
Phase 1 Cost> CTOL
Switch to Phase 1
Infeasible start Phase 1
Set cost row
Set π vector
Return

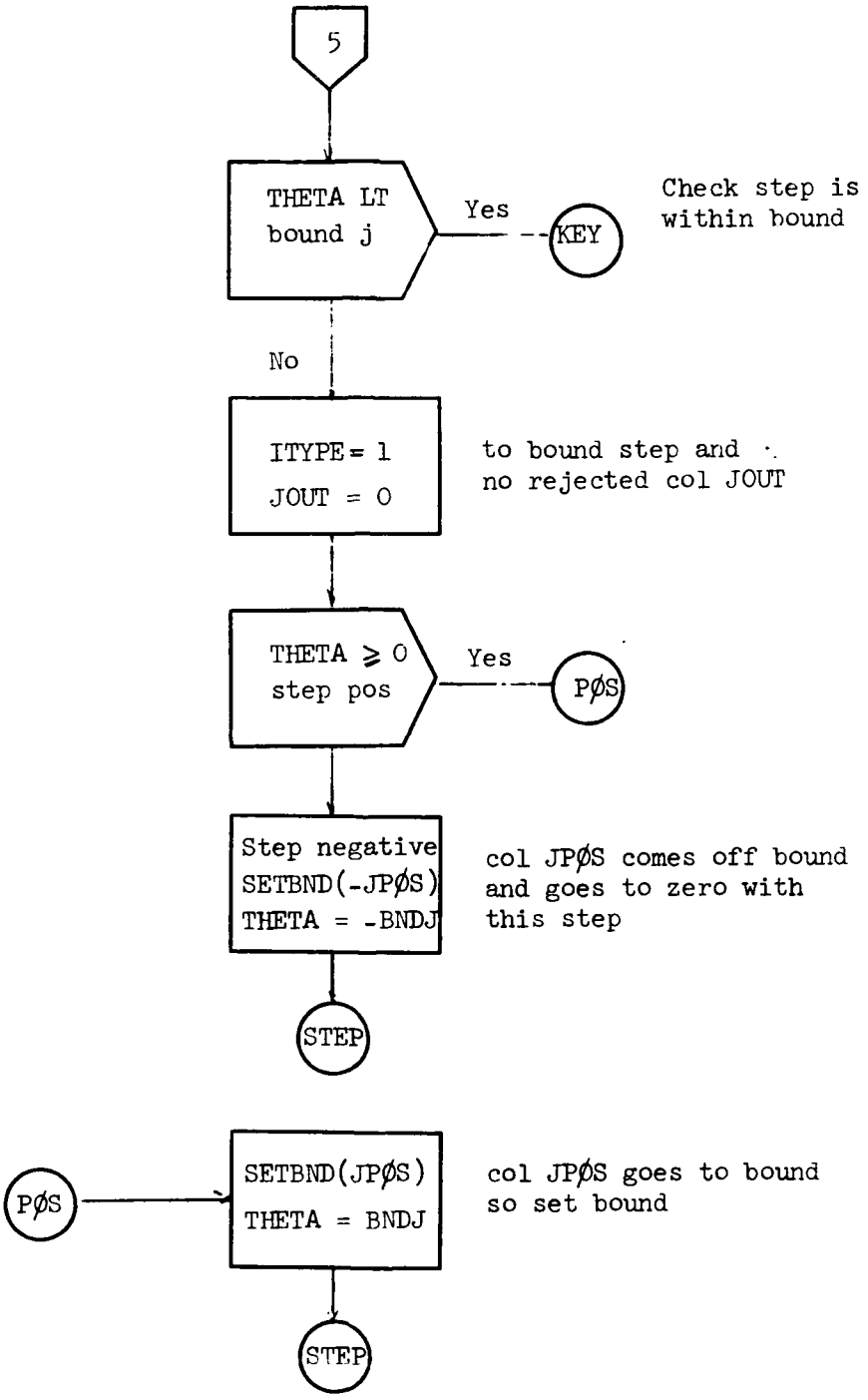
PRIMAL runs the 2 phase revised simplex algorithm from both phases and exits via EXIT.

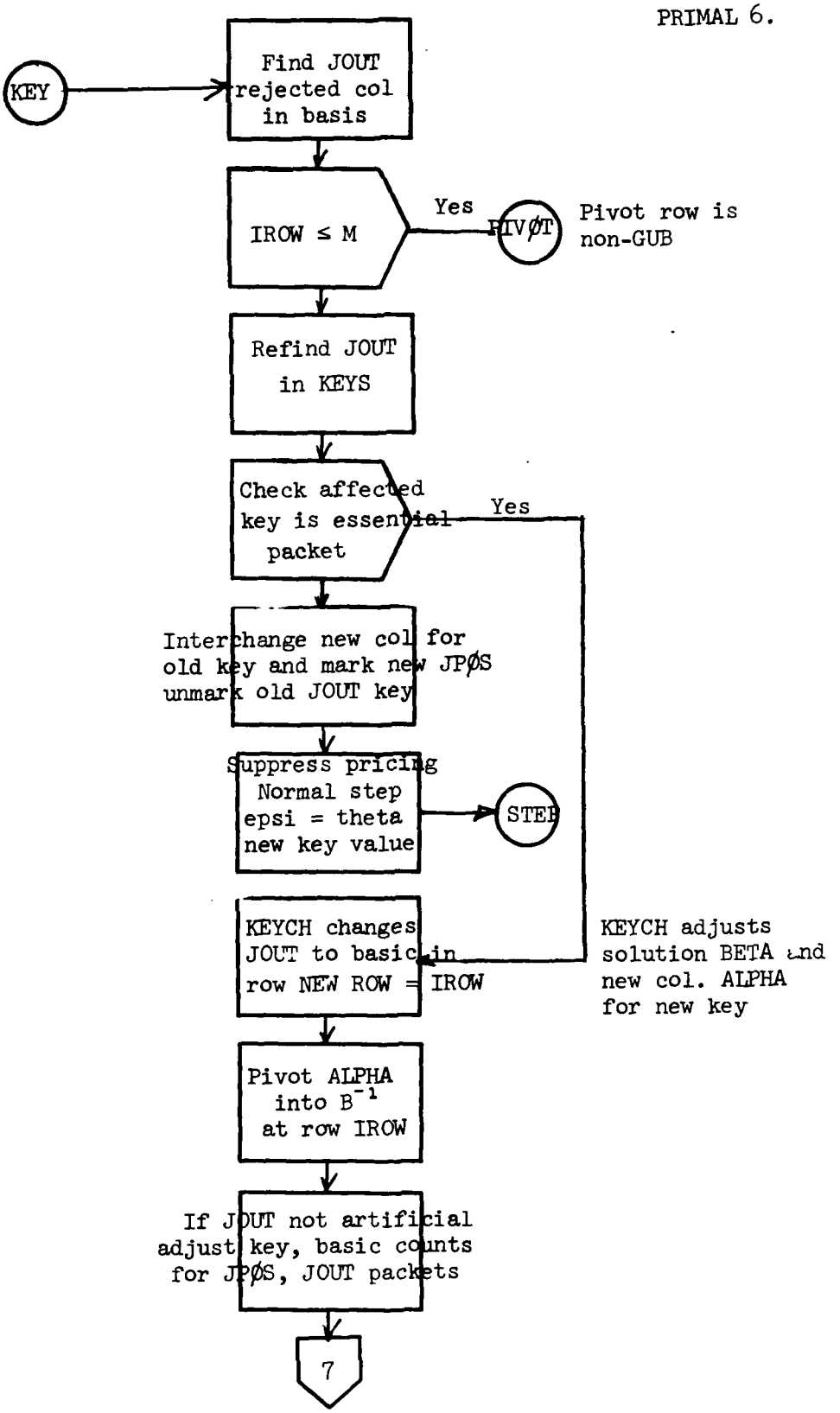


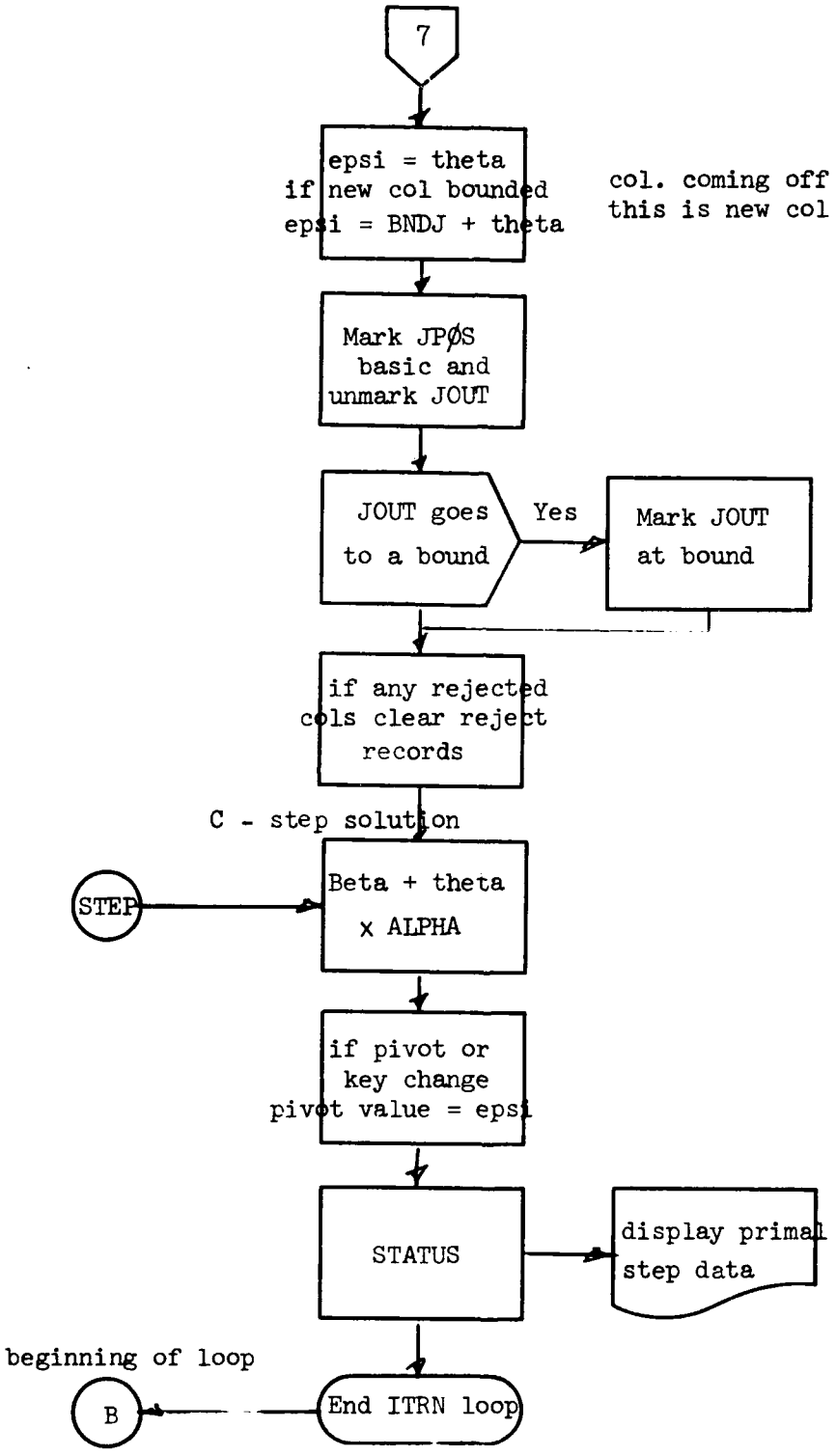

2
Zero all data
COLUMN prices out in-core columns and finds best unrejected column
NEW COL
COLUMN for col JCOL
JCOL is location in core = 1 to JNCORE
Check JCOL ≠ 0 XCHECK
yes
3
C - termination conditions checked
IPHASE = 2
yes
END 2
Optimum phase 2 ending
Phase 1 cost less than CTOL
yes
END 1
Optimum phase 1 ending.
NOFEAS RETURN
no feasible solution since phase 1 cost not zero

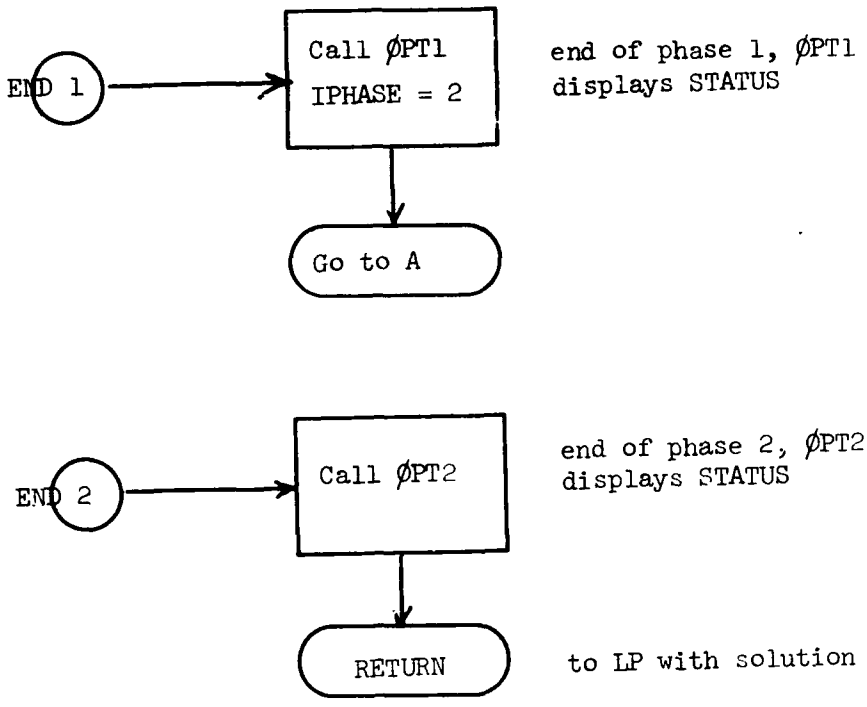

3
Disc column no. JPØS and bound BNDJ for column JCOL (in-CORE)
ITYPE = 1 unbounded
= 2 to a bound
Row for row IROW, step THETA and step type ITYPE
XCheck
no row found
No
IROW = 0
Call Unbnd return
unbounded termination
DEG
ok
Check pivot
No good
Report bad pivot if more than 3
Rejected column data
Reject column and count rejections
5 rejection exactly
Reinvert basis and start again
4


4
Less than 100 rejects
Yes
NEW COL
ERROR
Too many reject vectors
Phase 2
Yes
END 2
No
Escape and quit
Cost change ≥ CTOL
Yes
DEG
5
No
Reject column and count in NDEG
Yes
Last good column
(NDJS is 1 at last column)
No
New col if few tried
NEW COL
limit NDEGLM = 0
5


5
THETA LT bound j
Yes
KEY
Check step is within bound
No
ITYPE = 1
JOUT = 0
to bound step and no rejected col JOUT
THETA ≥ 0 step pos
Yes
PØS
Step negative
SETBND(-JPØS)
THETA = -BNDJ
col JPØS comes off bound and goes to zero with this step
STEP
PØS
SETBND(JPØS)
THETA = BNDJ
col JPØS goes to bound so set bound
STEP


KEY
Find JOUT rejected col in basis
IROW ≤ M
Yes
PIVØT
Pivot row is non-GUB
Refind JOUT in KEYS
Check affected key is essential packet
Yes
Interchange new col for old key and mark new JPØS unmark old JOUT key
Suppress pricing Normal step epsi = theta new key value
STEP
KEYCH changes JOUT to basic in row NEW ROW = IROW
KEYCH adjusts solution BETA and new col. ALPHA for new key
Pivot ALPHA into B-1 at row IROW
If JOUT not artificial adjust key, basic counts for JPØS, JOUT packets
7


7
epsi = theta
if new col bounded
epsi = BNDJ + theta
col. coming off a bound
this is new col value
Mark JPØS
basic and
unmark JOUT
JOUT goes
to a bound
Yes
Mark JOUT
at bound
if any rejected
cols clear reject
records
C - step solution
STEP
Beta + theta
x ALPHA
if pivot or
key change
pivot value = epsi
STATUS
display primal
step data
beginning of loop
B
End ITRN loop



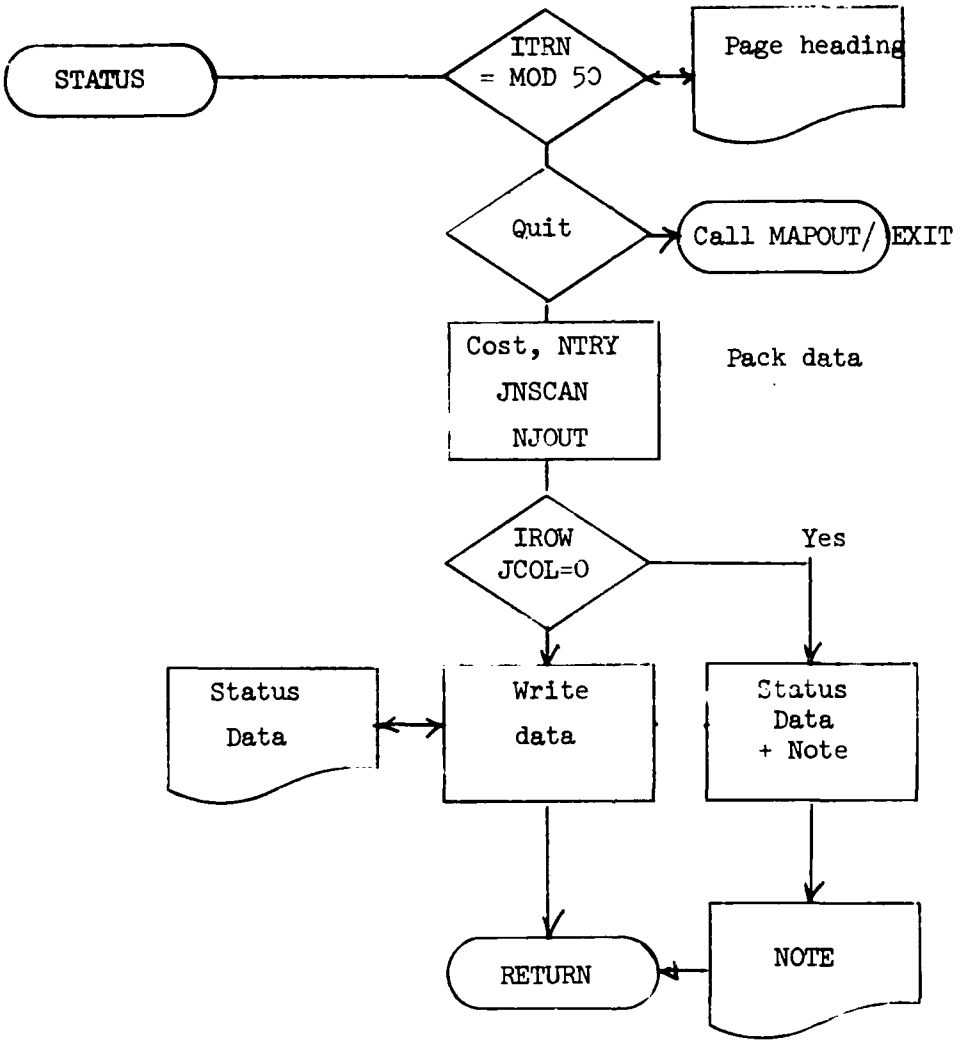
end of phase 1, ØPT1 displays STATUS

end of phase 2, ØPT2 displays STATUS

to LP with solution

Subroutine STATUS

STATUS prints BRIMAL data

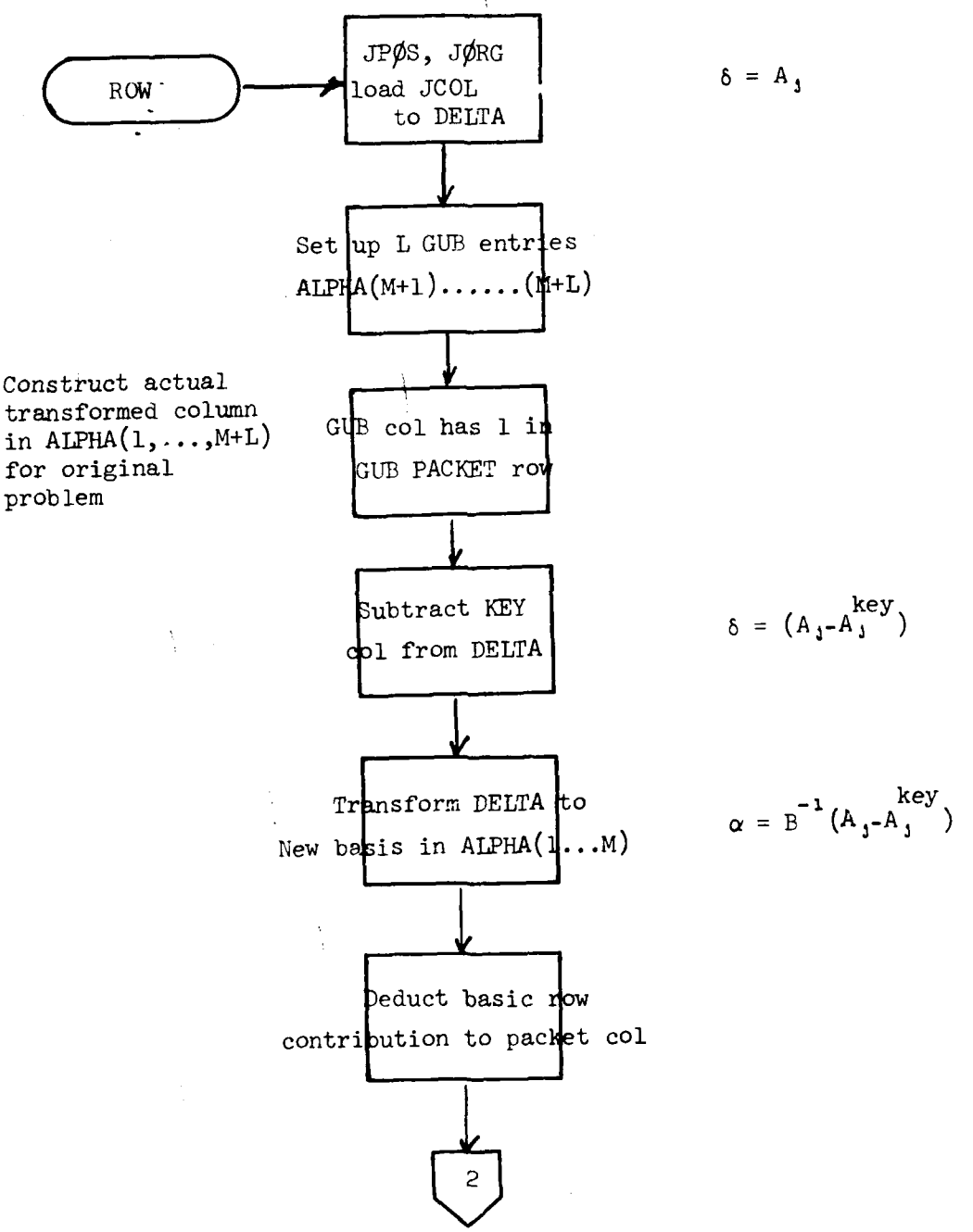


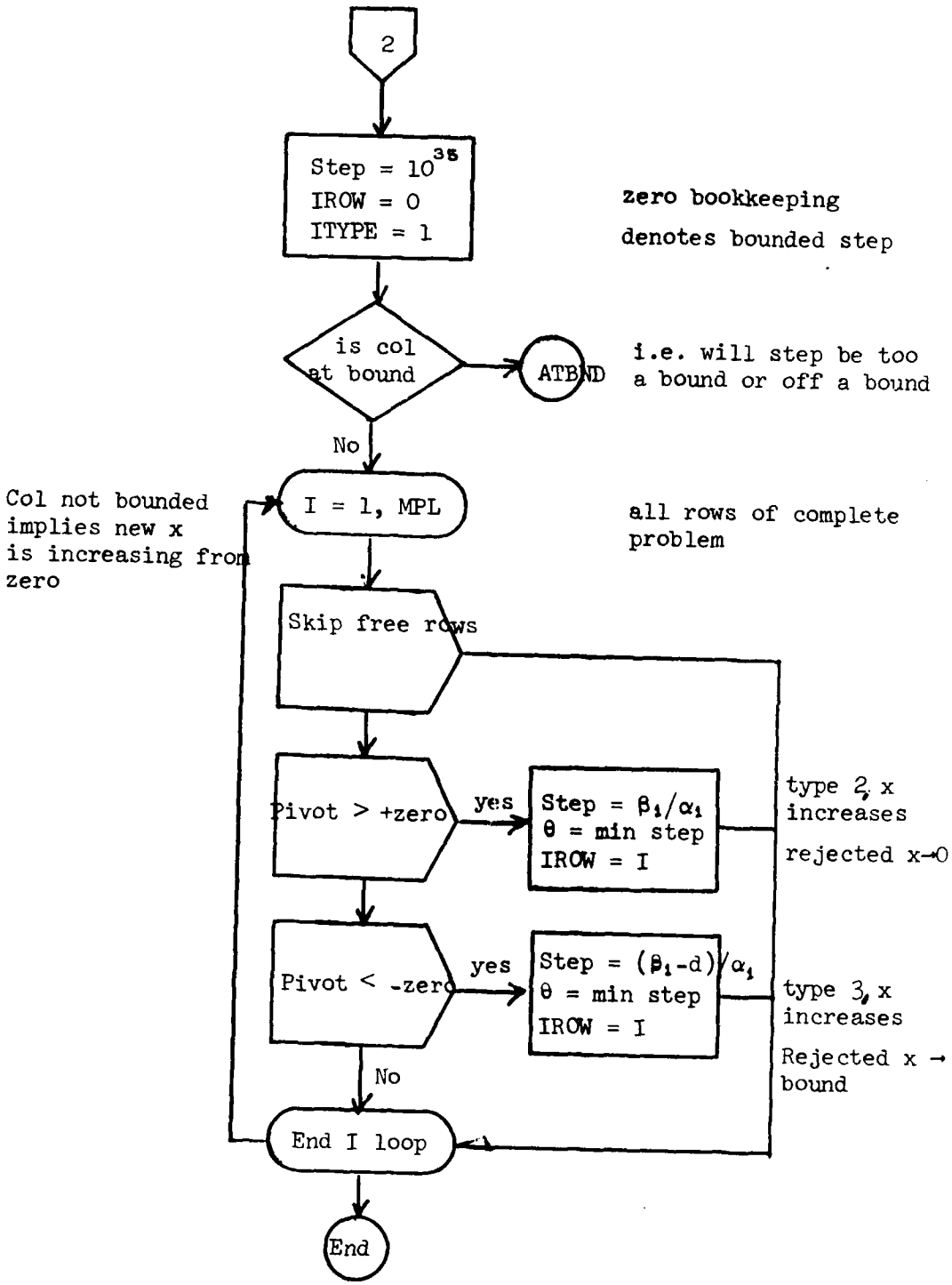
ERRØR - triple prints error messages

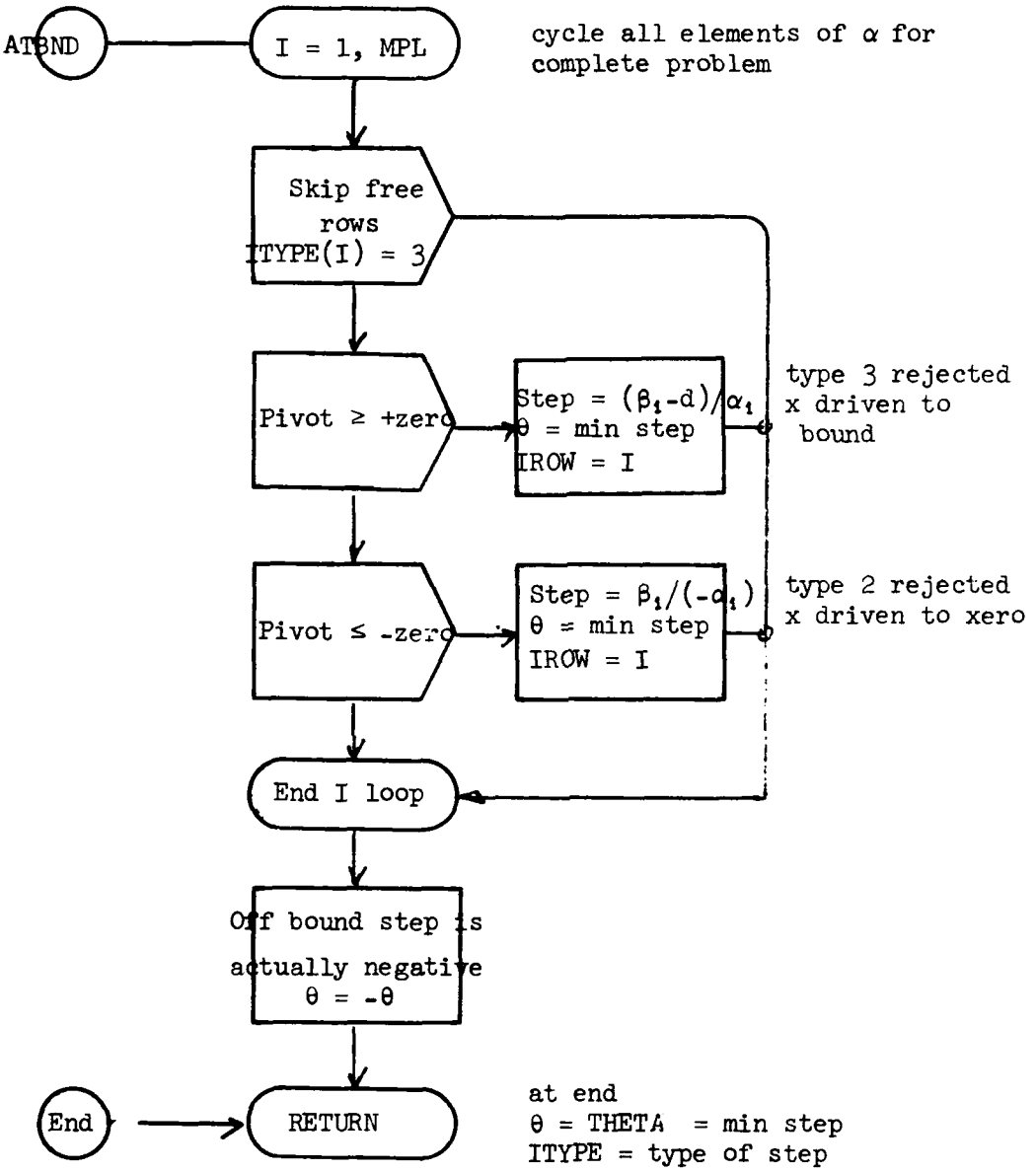
MESSG, MSSG } single print error messages and print time in seconds since start of run.

Subroutine ROW

ROW computes curren representation of selected column JCOL in core ALPHA then finds step MAX THETA which preserves feasibility.




2
Step = 10^{35}
IROW = 0
ITYPE = 1
zero bookkeeping
denotes bounded step
is col at bound
ATBND
i.e. will step be too a bound or off a bound
No
Col not bounded implies new x is increasing from zero
I = 1, MPL
all rows of complete problem
Skip free rows
Pivot > +zero
yes
Step = β_i/α_i
θ = min step
IROW = I
type 2, x increases
rejected x→0
Pivot < -zero
yes
Step = $(\beta_i - d)/\alpha_i$
θ = min step
IROW = I
type 3, x increases
Rejected x → bound
No
End I loop
End

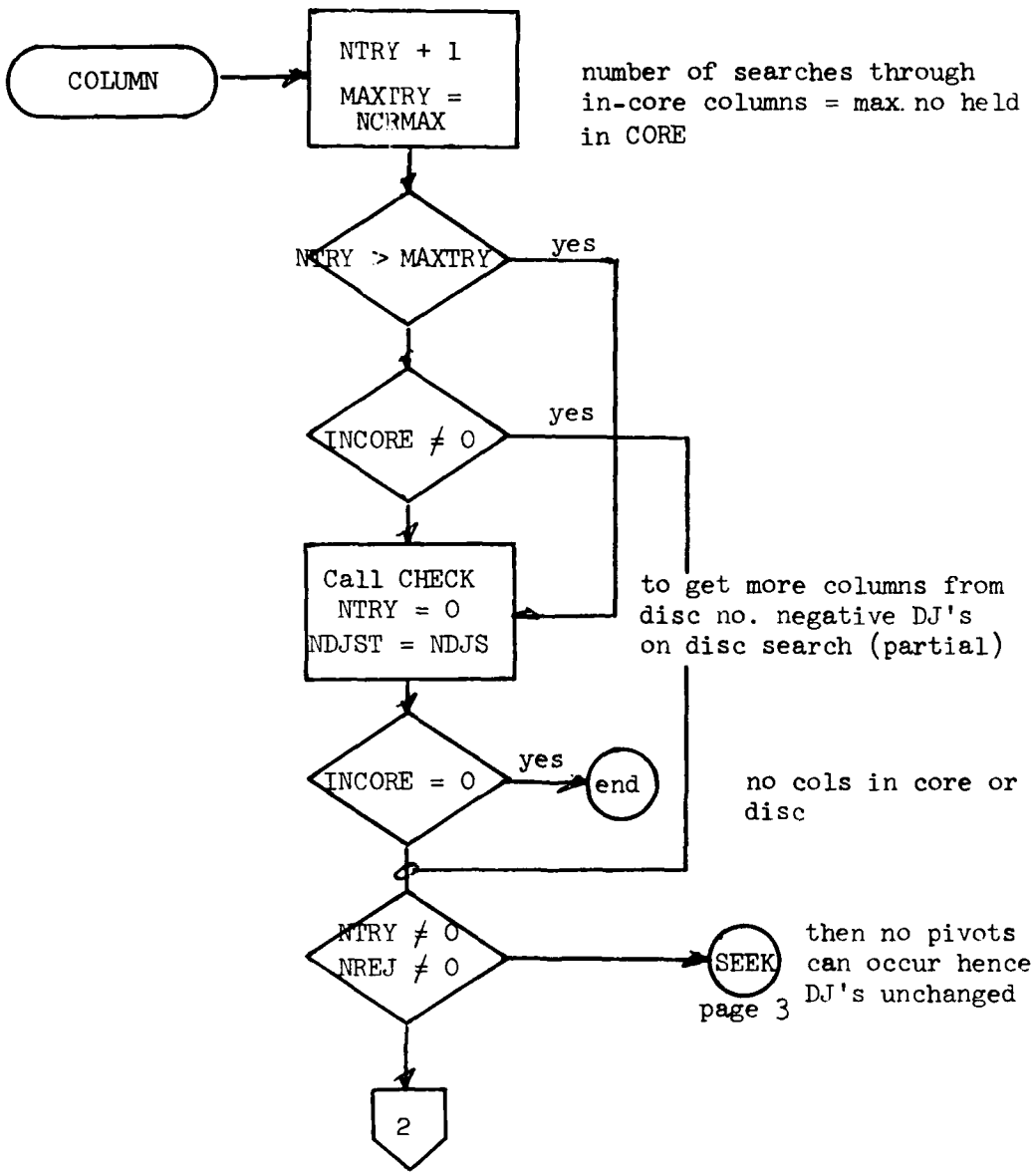


N.B. IROW ≤ M ⇒ pivot non-GUB row

> M ⇒ pivot on GUB row

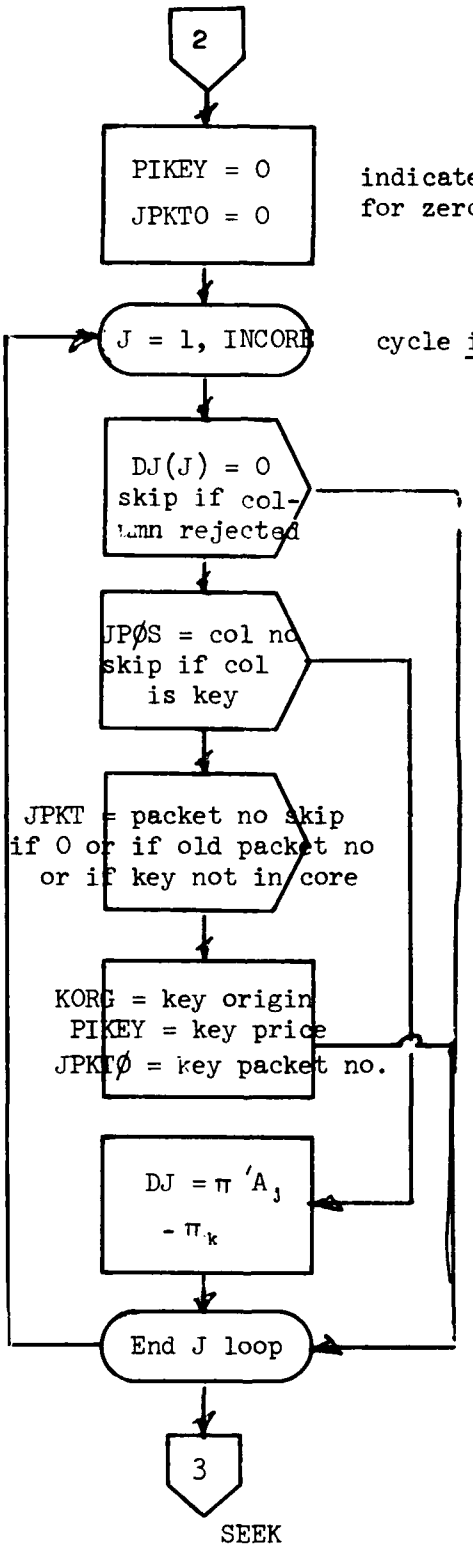
Subroutine COLUMN COLUMN 1.

COLUMN selects a column JCOL from among vectors in core in AJ space.
If no columns price out, it calls CHECK to search disc for replenishment.



COLUMN 2.

Reprices old columns in core unless the prices obviously haven't changed (same β^{-1}).



indicates no key price held for zero packet (old packet)

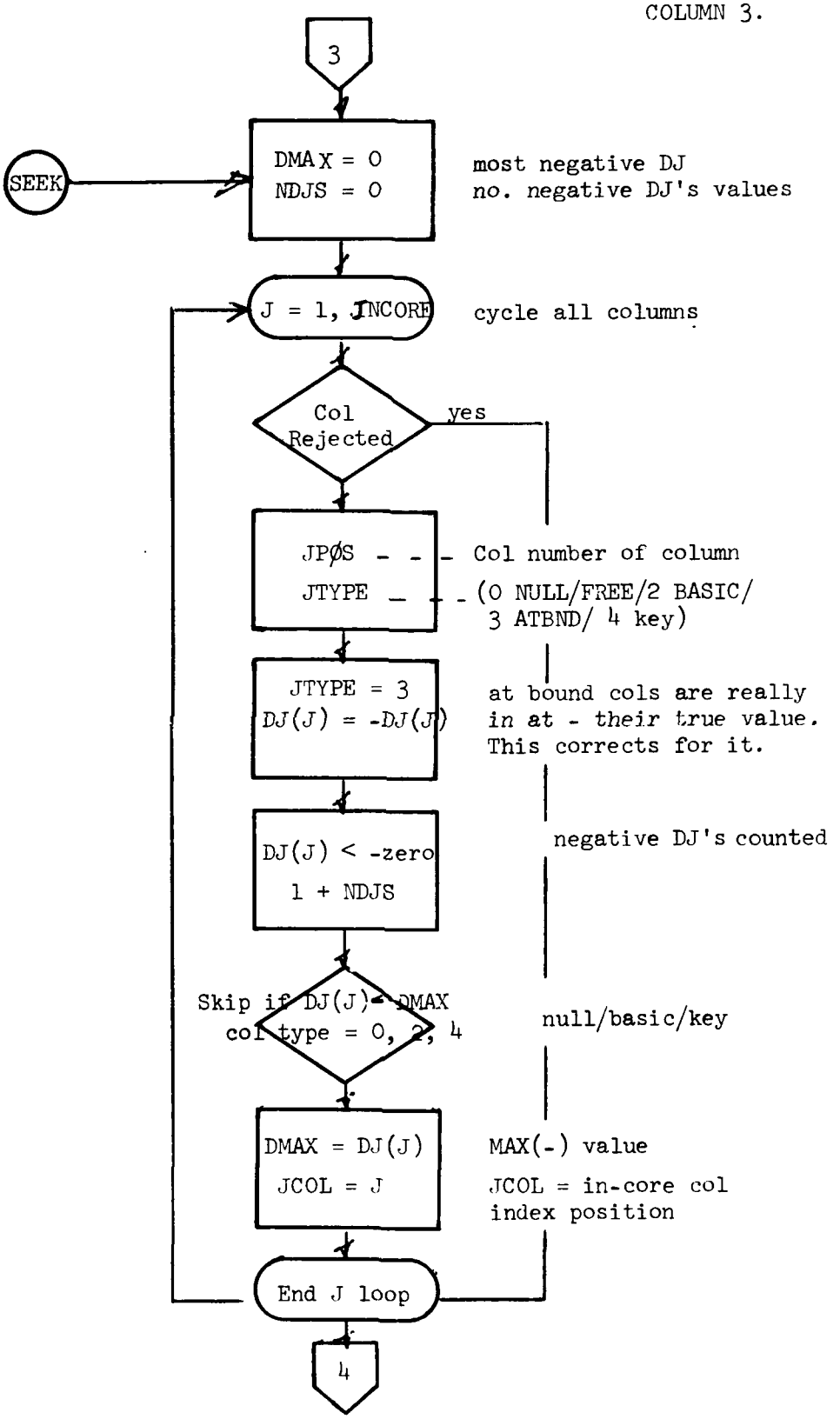
cycle in-core columns

JPØS file col. no on disc

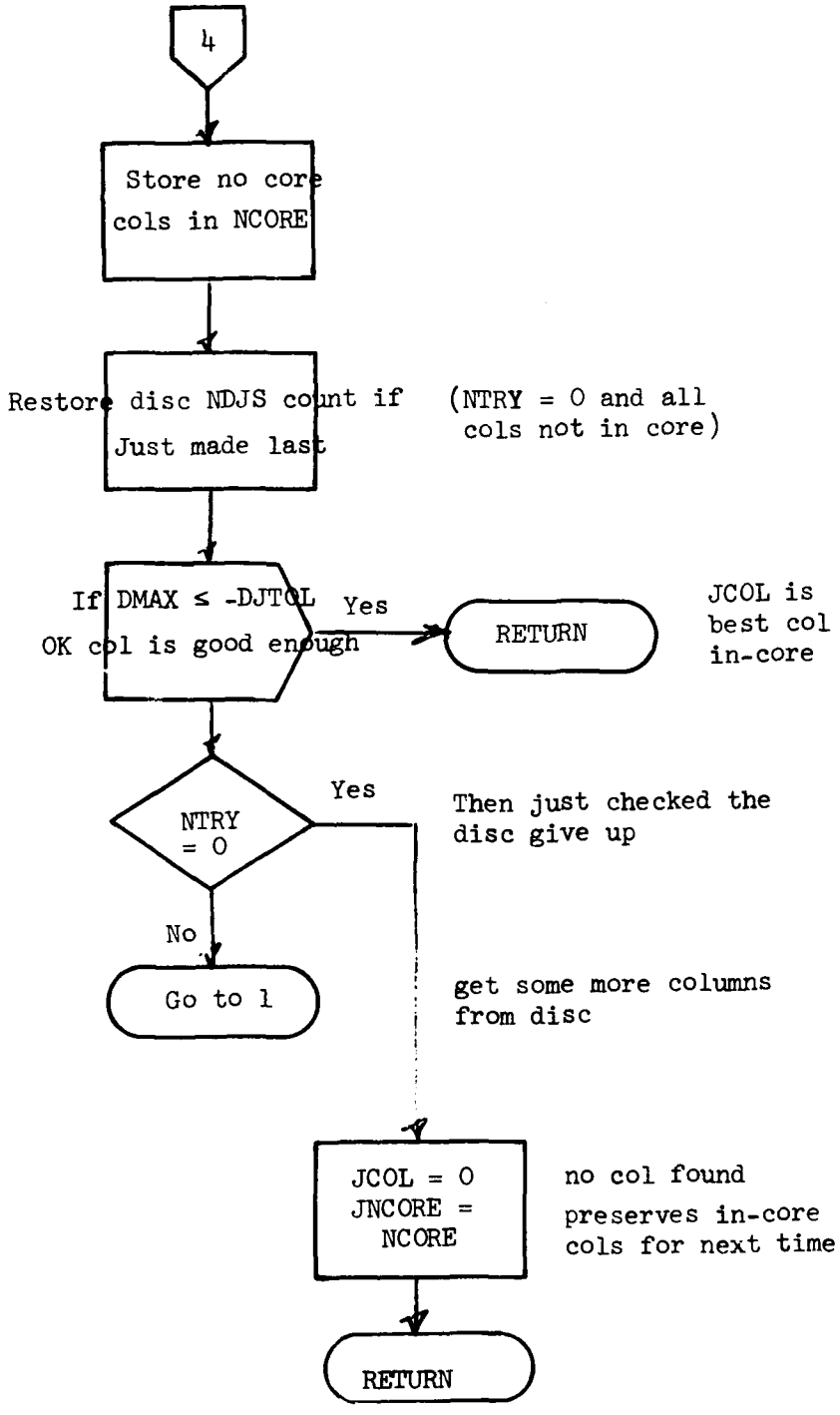
new packet, recompute price and store packet no.

price for GUB problem if non GUB, π_k = PIKEY ≡ 0
π is IC row of B^{-1}

COLUMN 3.

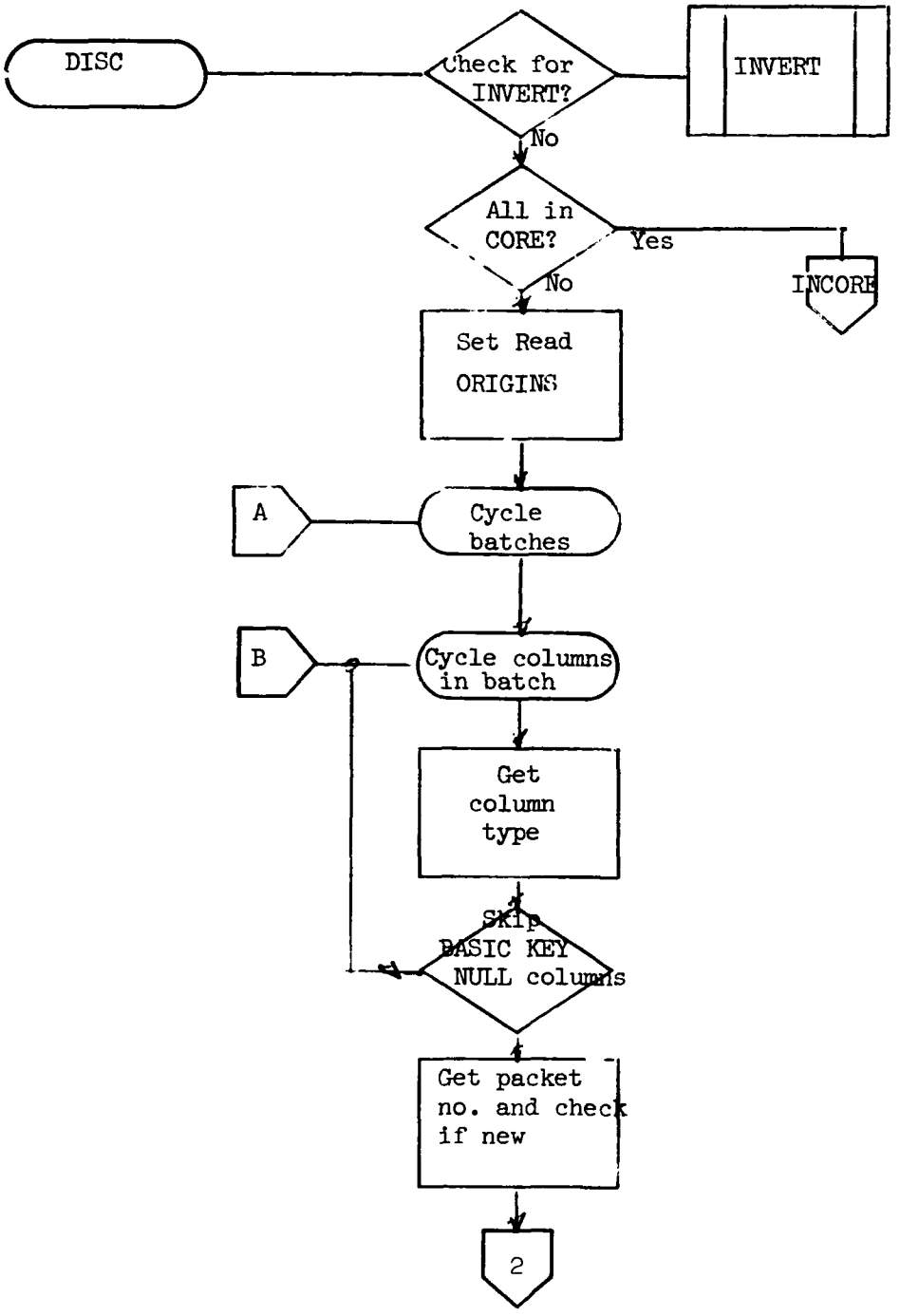

3
SEEK
DMAX = 0
NDJS = 0
most negative DJ
no. negative DJ's values
J = 1, JNCORE
cycle all columns
Col Rejected
yes
JPØS - -
JTYPE _ _
Col number of column
(0 NULL/FREE/2 BASIC/ 3 ATBND/ 4 key)
JTYPE = 3
DJ(J) = -DJ(J)
at bound cols are really in at - their true value. This corrects for it.
DJ(J) < -zero
1 + NDJS
negative DJ's counted
Skip if DJ(J) ≥ DMAX
col type = 0, 2, 4
null/basic/key
DMAX = DJ(J)
JCOL = J
MAX(-) value
JCOL = in-core col index position
End J loop
4

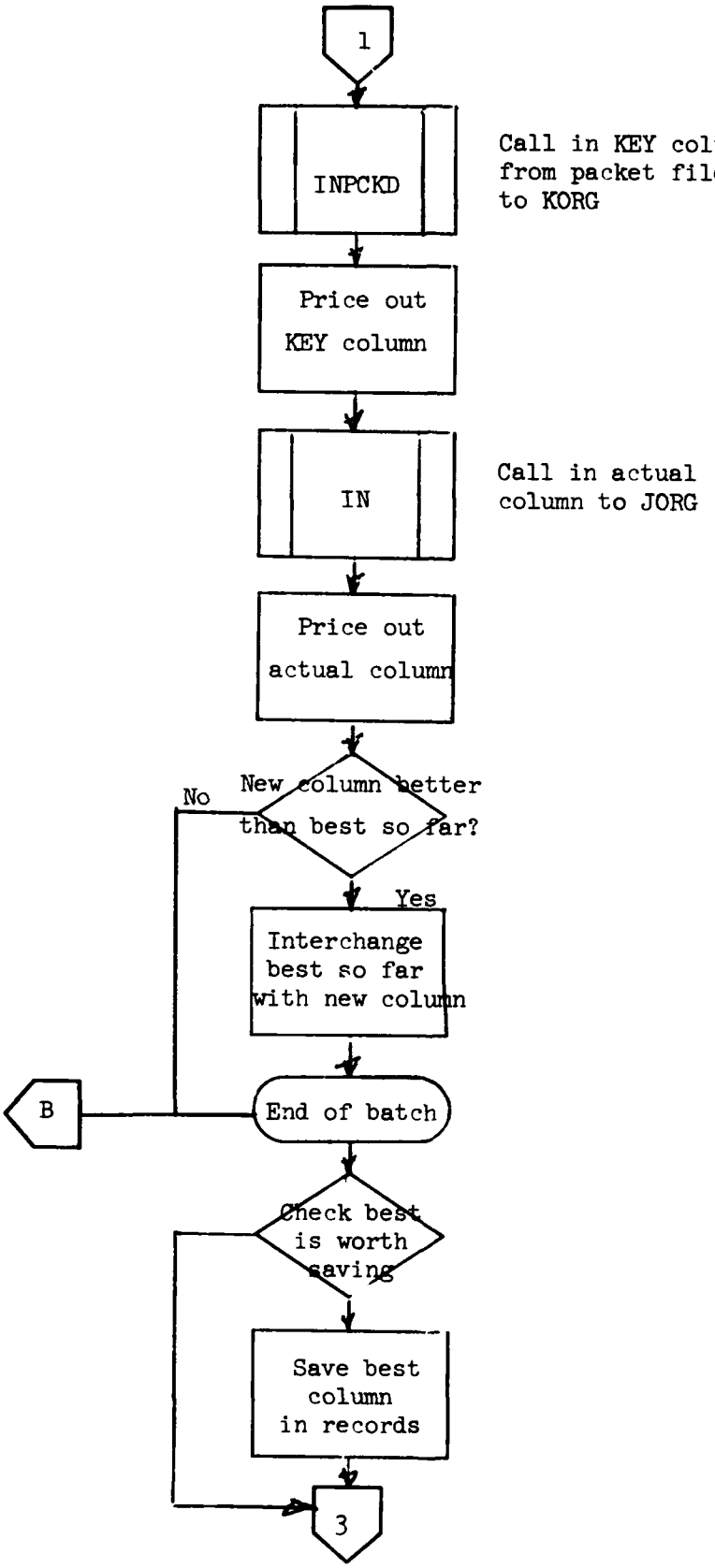
COLUMN 4.


4
Store no core cols in NCORE
Restore disc NDJS count if Just made last
(NTRY = 0 and all cols not in core)
If DMAX ≤ -DJTOL OK col is good enough
Yes
RETURN
JCOL is best col in-core
NTRY = 0
Yes
Then just checked the disc give up
No
Go to 1
get some more columns from disc
JCOL = 0
JNCORE = NCORE
no col found
preserves in-core cols for next time
RETURN

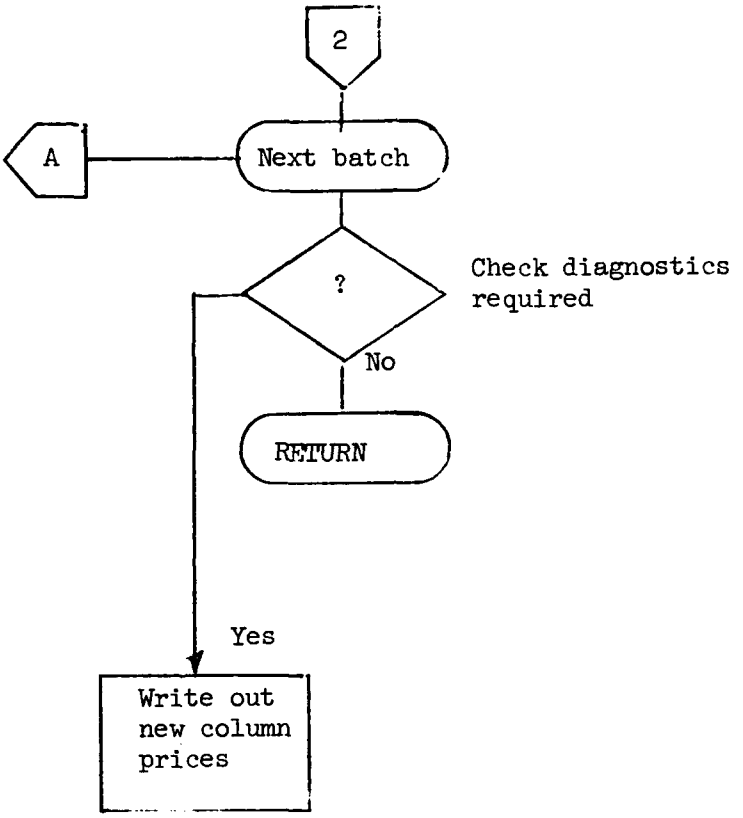
Subroutine DISC DISC 1

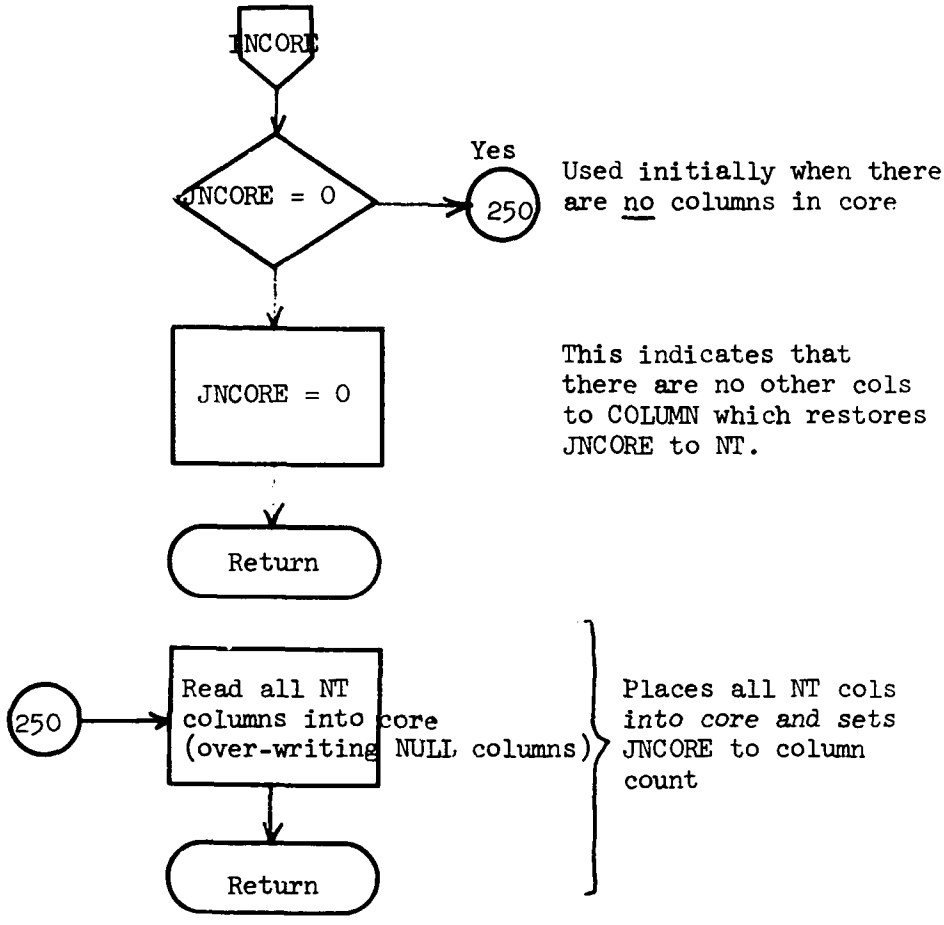
Checks if an inverse is necessary and then checks the DISC files IA1, IA2 for more useful columns using IN and INPCKD.




1
INPCKD
Call in KEY column from packet file to KORG
Price out KEY column
IN
Call in actual column to JORG
Price out actual column
New column better than best so far?
No
Yes
Interchange best so far with new column
B
End of batch
Check best is worth saving
Save best column in records
3

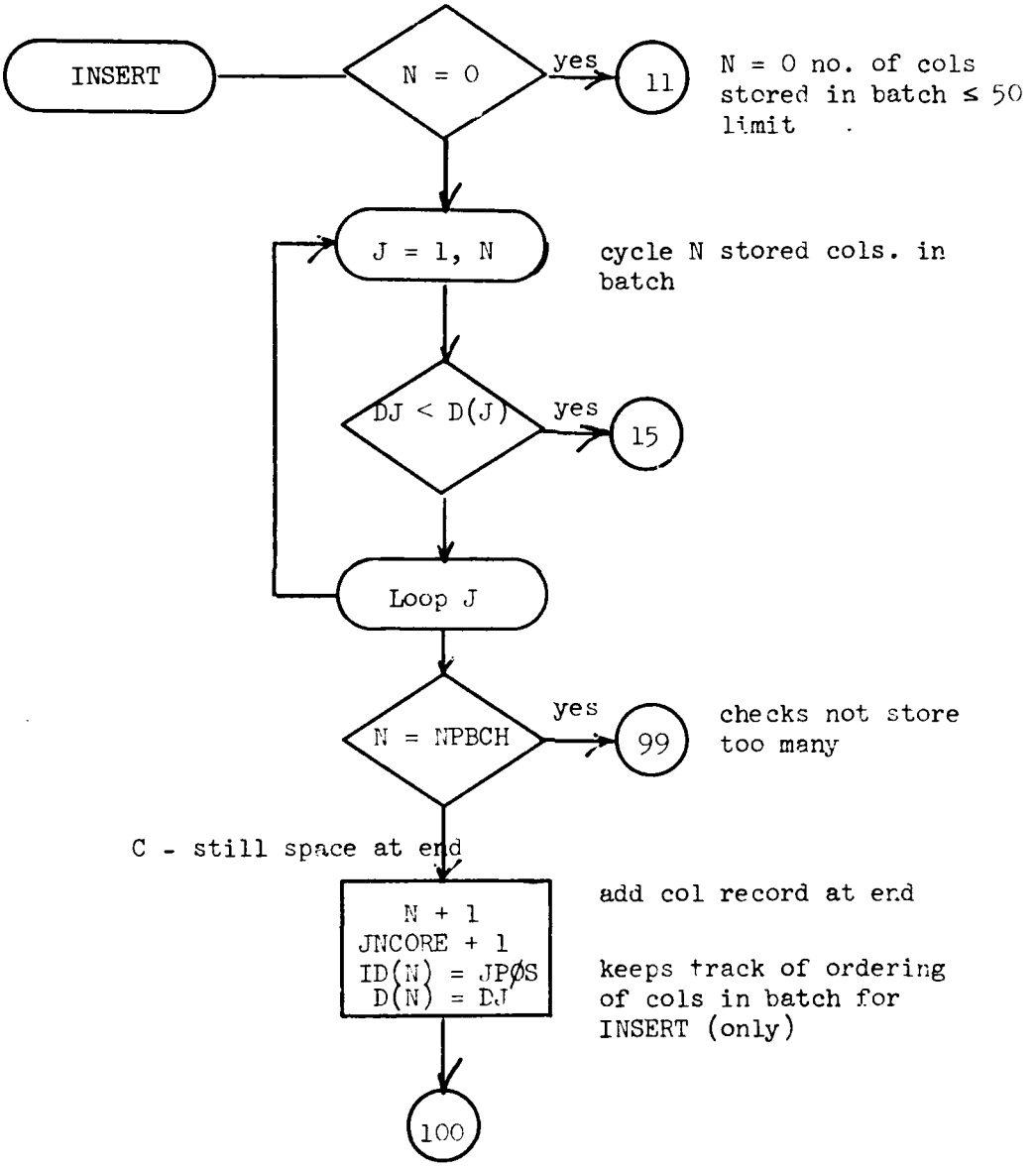
DISC 3

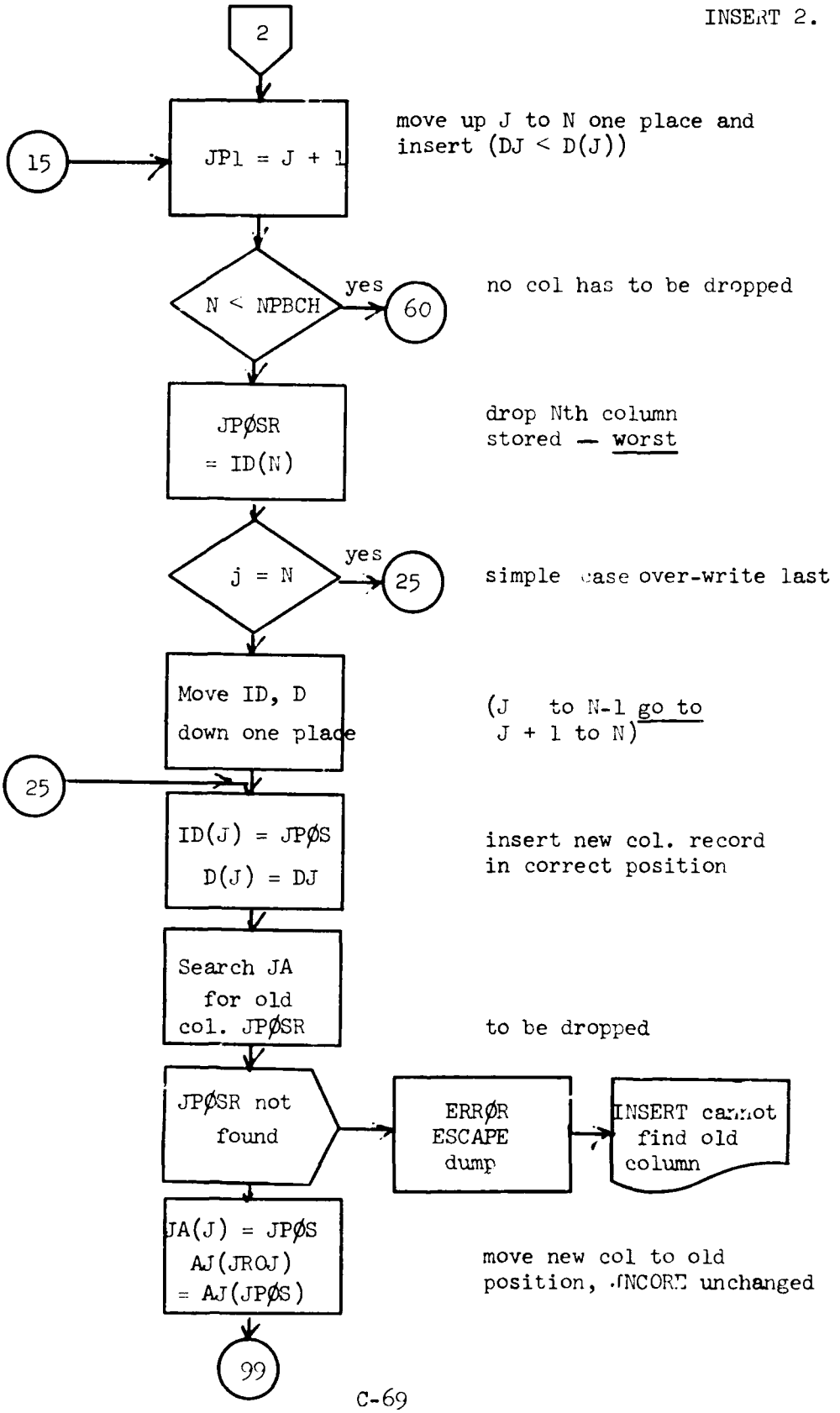

2
A
Next batch
?
Check diagnostics required
No
RETURN
Yes
Write out new column prices



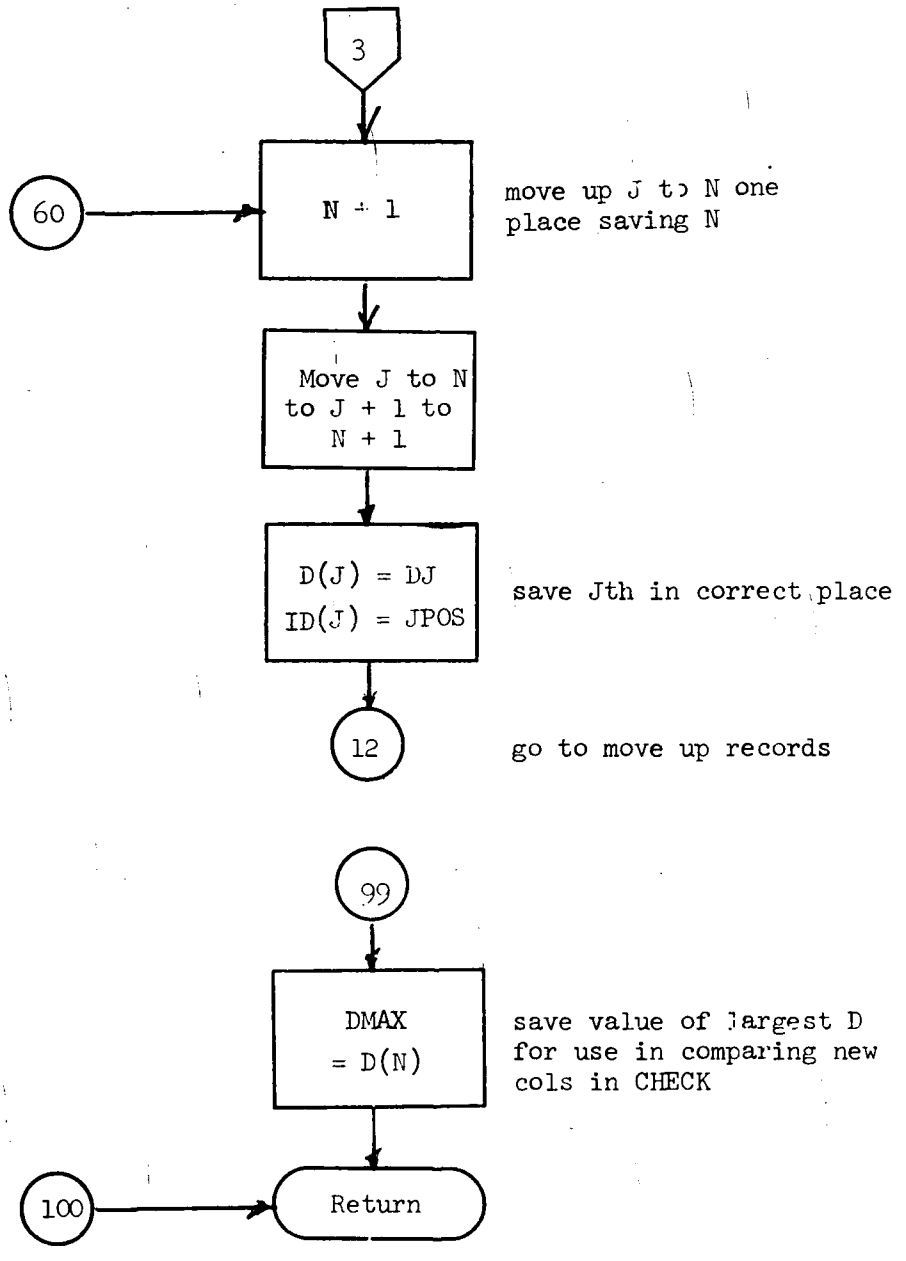
N.B. Once the columns are read into core, they stay there because COLUMN always restores JNCORE to NT and keeps track of them at the end of each phase.

INSERT used by CHECK to order columns selected in the batch. It keeps track of worst column stored of the batch and over writes it if a better one is offered.

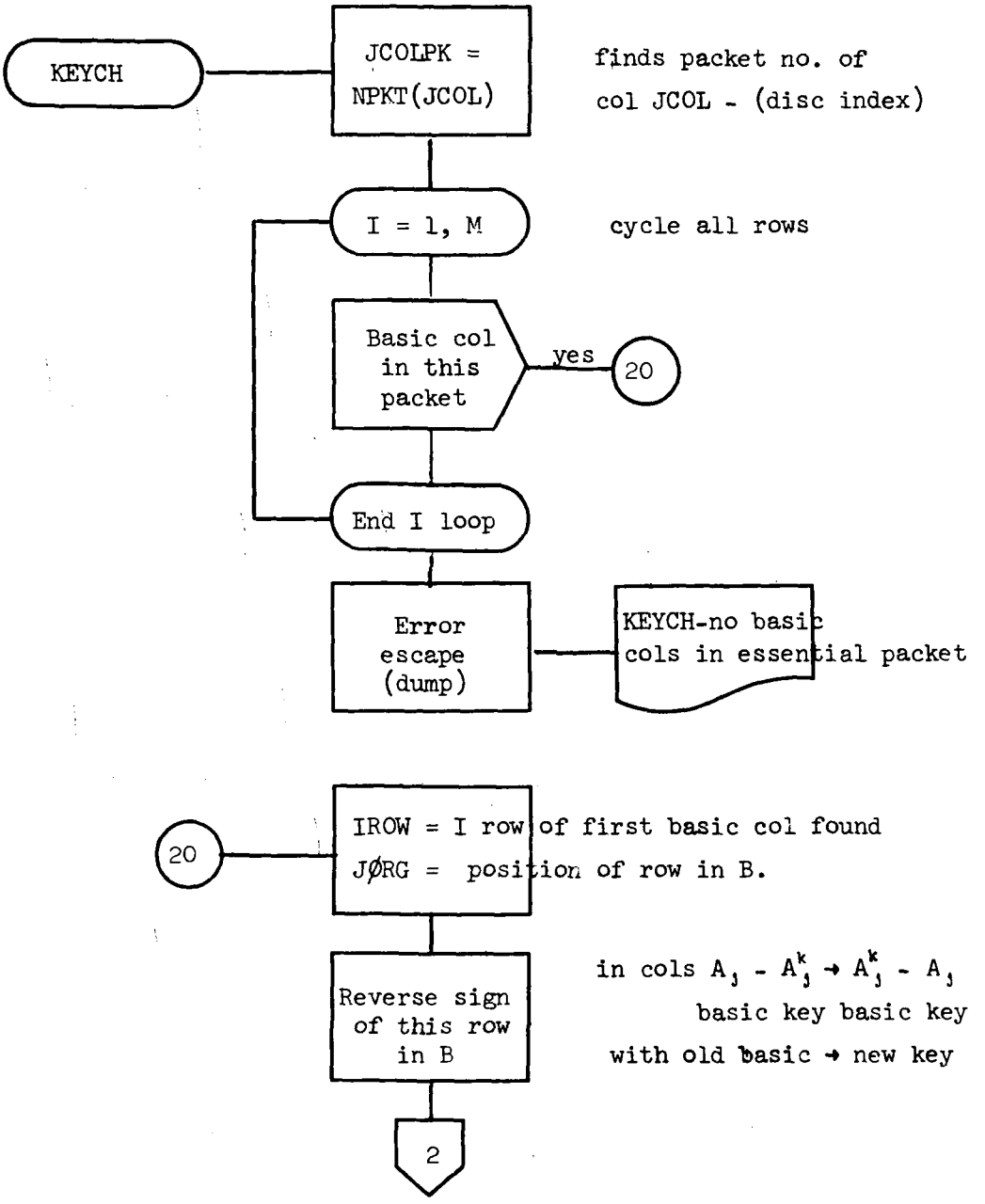


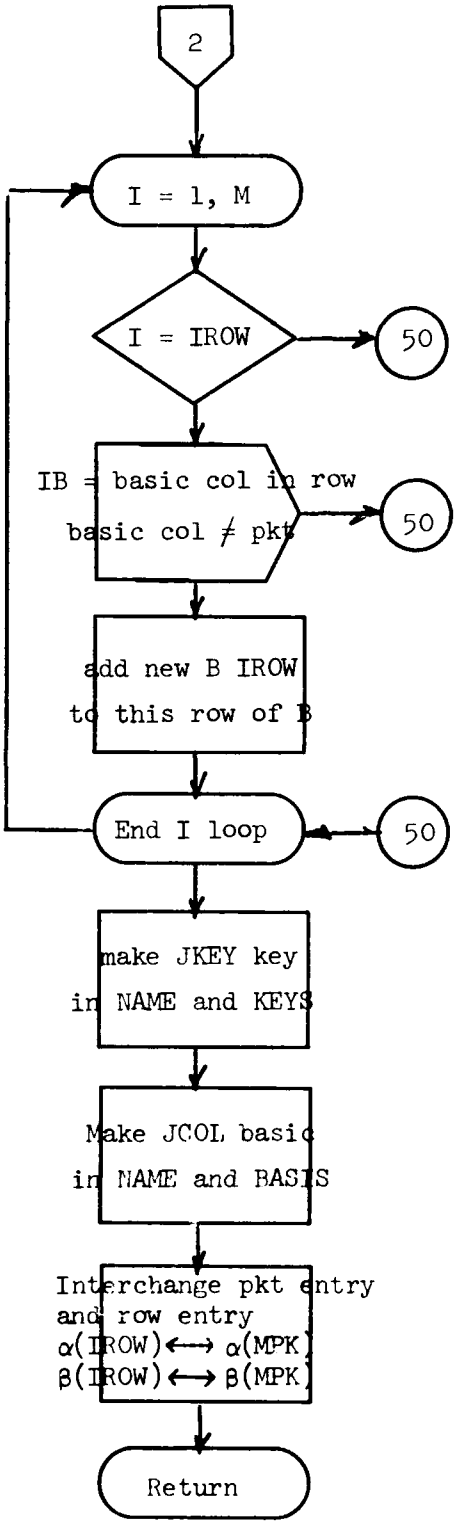

2
15
JP1 = J + 1
move up J to N one place and insert (DJ < D(J))
N < NPBCH
yes
60
no col has to be dropped
JPØSR = ID(N)
drop Nth column stored — worst
j = N
yes
25
simple case over-write last
Move ID, D down one place
(J to N-1 go to J + 1 to N)
25
ID(J) = JPØS
D(J) = DJ
insert new col. record in correct position
Search JA for old col. JPØSR
to be dropped
JPØSR not found
ERRØR ESCAPE dump
INSERT cannot find old column
JA(J) = JPØS
AJ(JROJ) = AJ(JPØS)
move new col to old position, NCORT unchanged
99

INSERT 3.


3
60
N + 1
move up J to N one place saving N
Move J to N to J + 1 to N + 1
D(J) = DJ
ID(J) = JPOS
save Jth in correct place
12
go to move up records
99
DMAX = D(N)
save value of largest D for use in comparing new cols in CHECK
100
Return

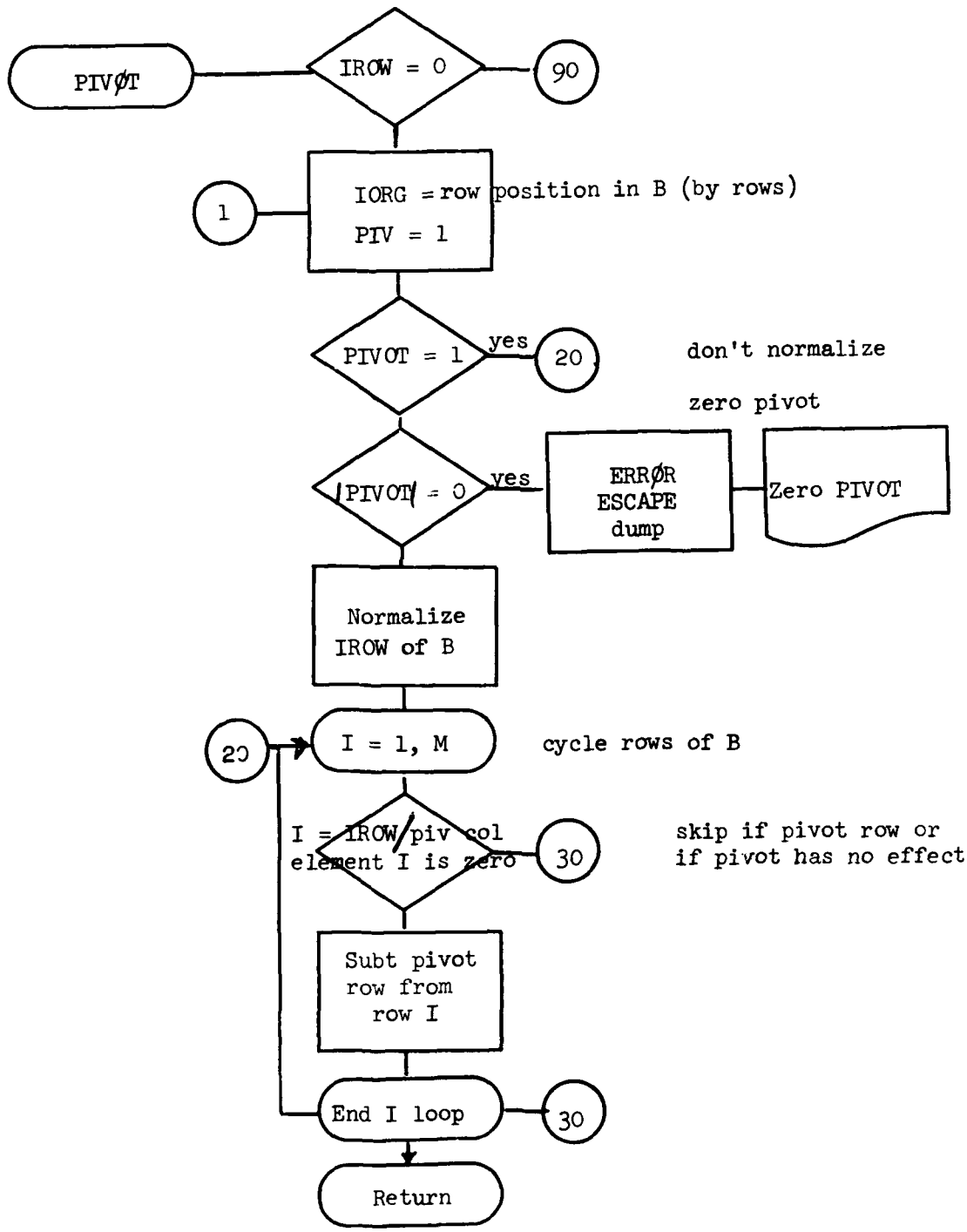
KEYCH changes key to make JCOL basic in some row IROW found, making old col key, and corrects α, β and B^{-1}.



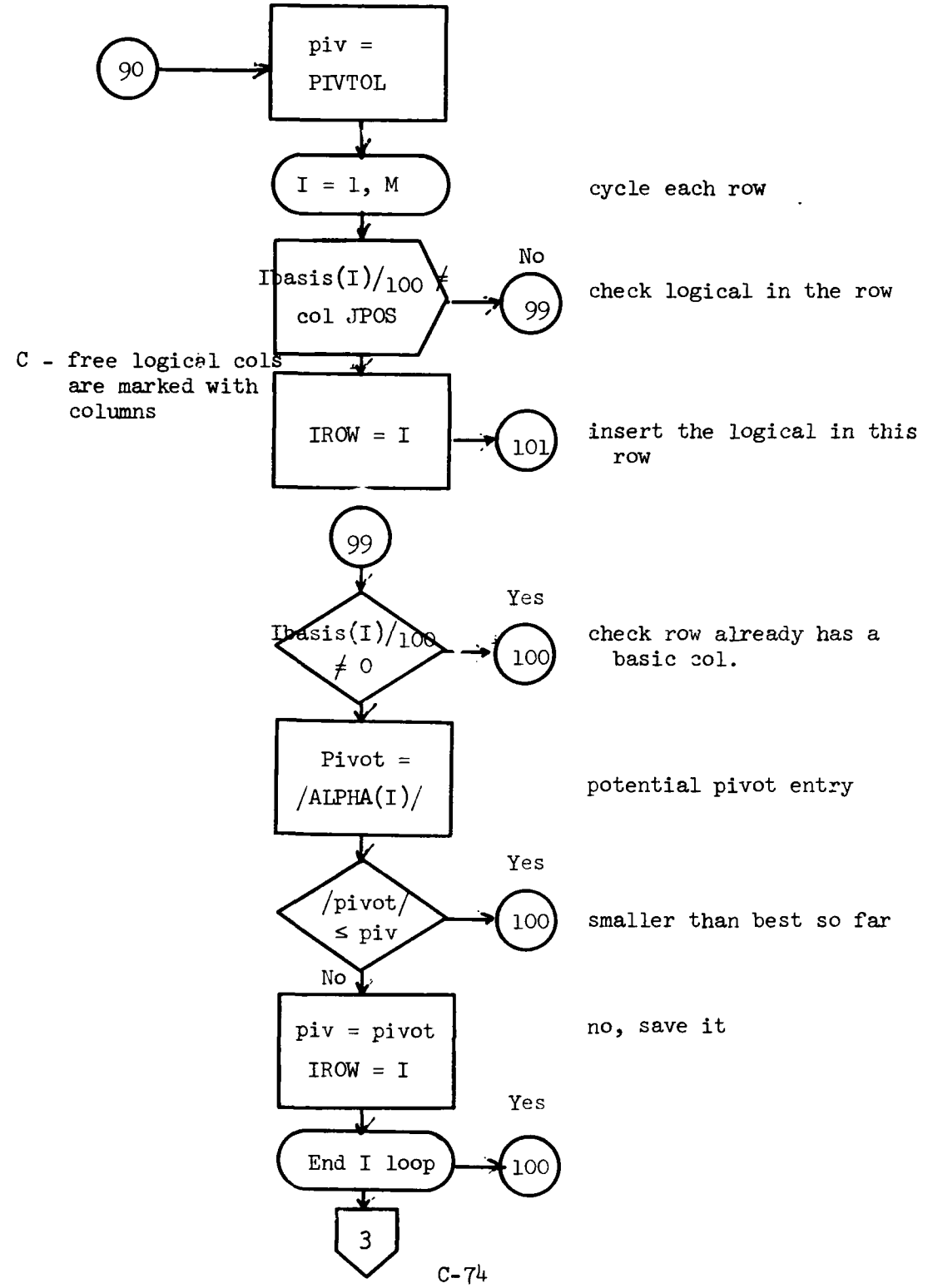


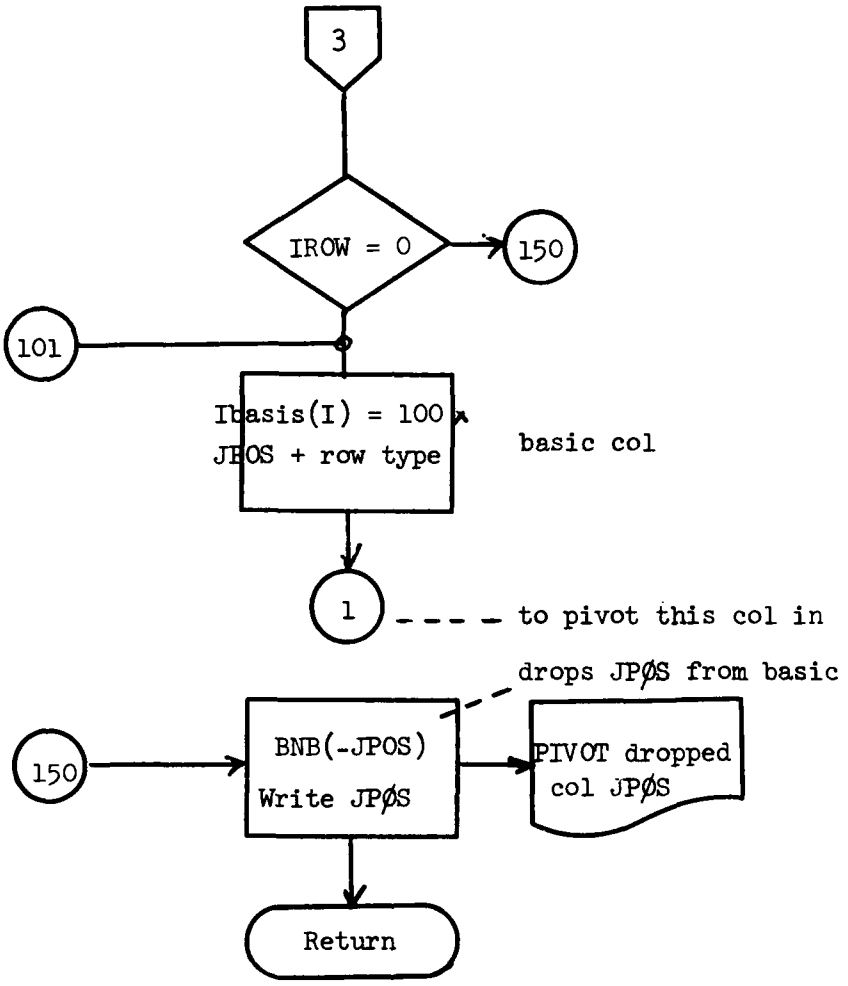
Rearrange B^{-1} in B for new key which was basic

PIVOT inserts current representation of column ALPHA into basic inverse B at IROW, if IROW = 0 it finds a slot for ALPHA or rejects it.

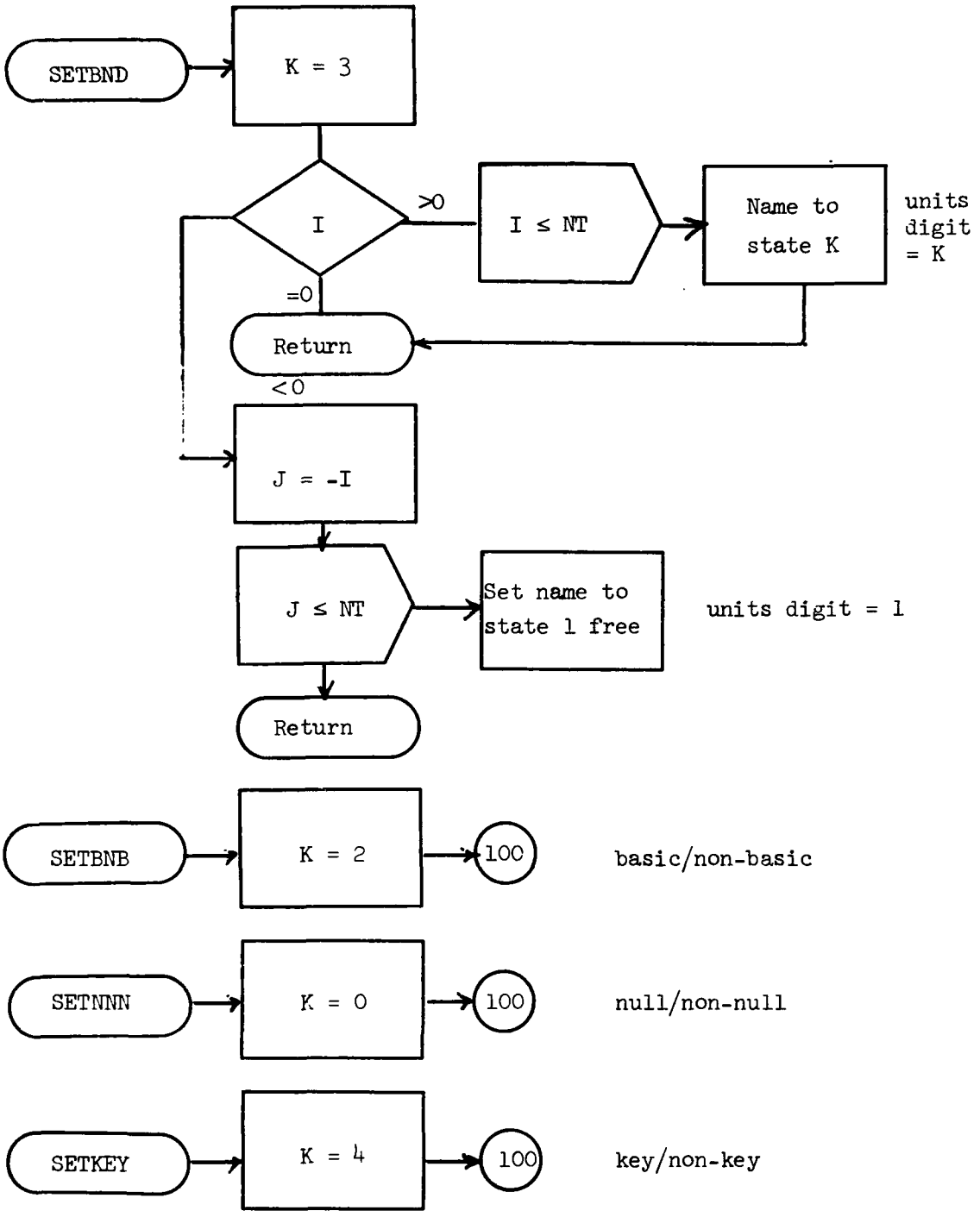


Find best row for ALPHA called from INVERT when row not known.




3
IROW = 0
150
101
Ibasis(I) = 100
JPOS + row type
basic col
1
to pivot this col in
drops JPØS from basic
150
BNB(-JPOS)
Write JPØS
PIVOT dropped
col JPØS
Return

SETBND, SETBNB, SETKEY, SETNNN all set or unset to state of a variable to bound/basic/key/null.

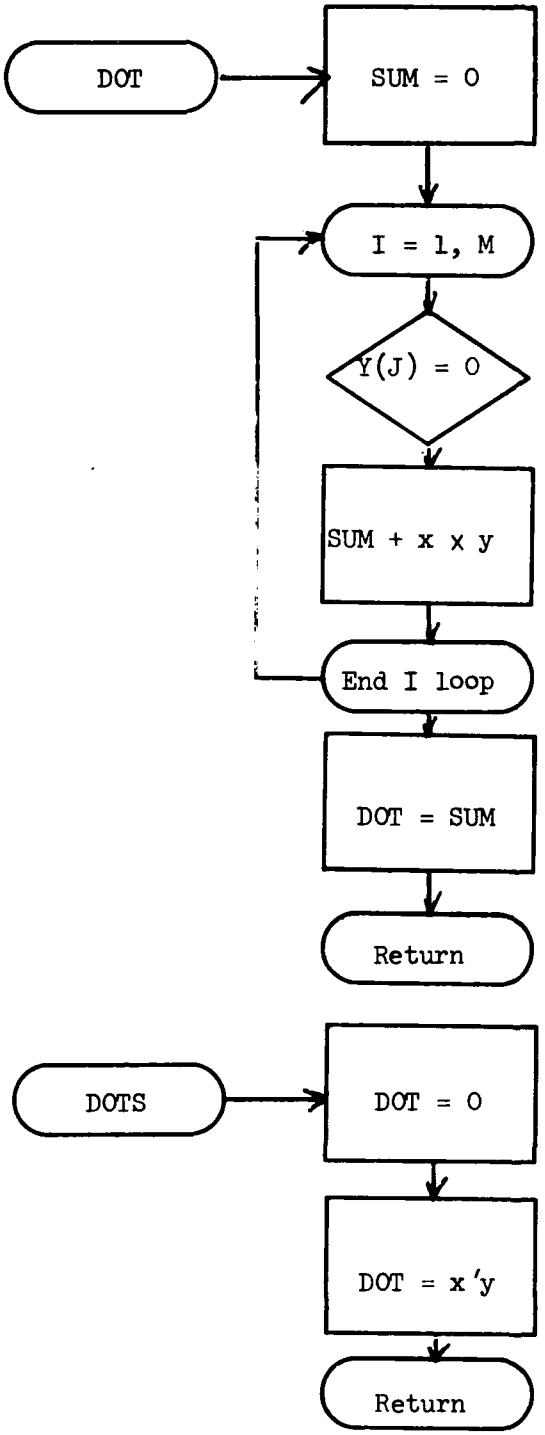


DOT
DOTS

FUNCTION DOT, DOTS

DOT and DOTS evaluate double and single precision inner products

DOT = x'y.



double precision accumalator

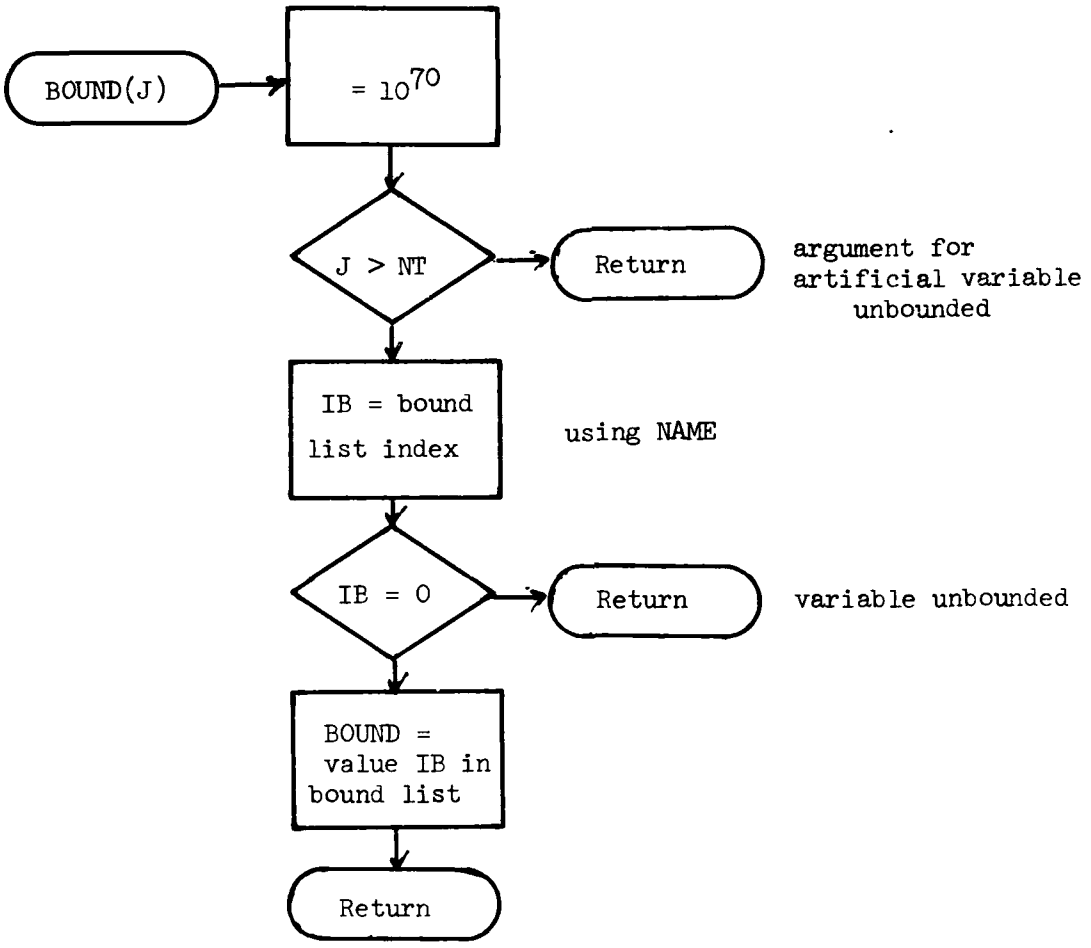
in x'y y elements are often zero (as used) avoid double precision manipulations for this case

Replace double answer to single

quick single precision version to save time

FUNCTION BOUND

BOUND - checks its argument and picks up the variable bound value.

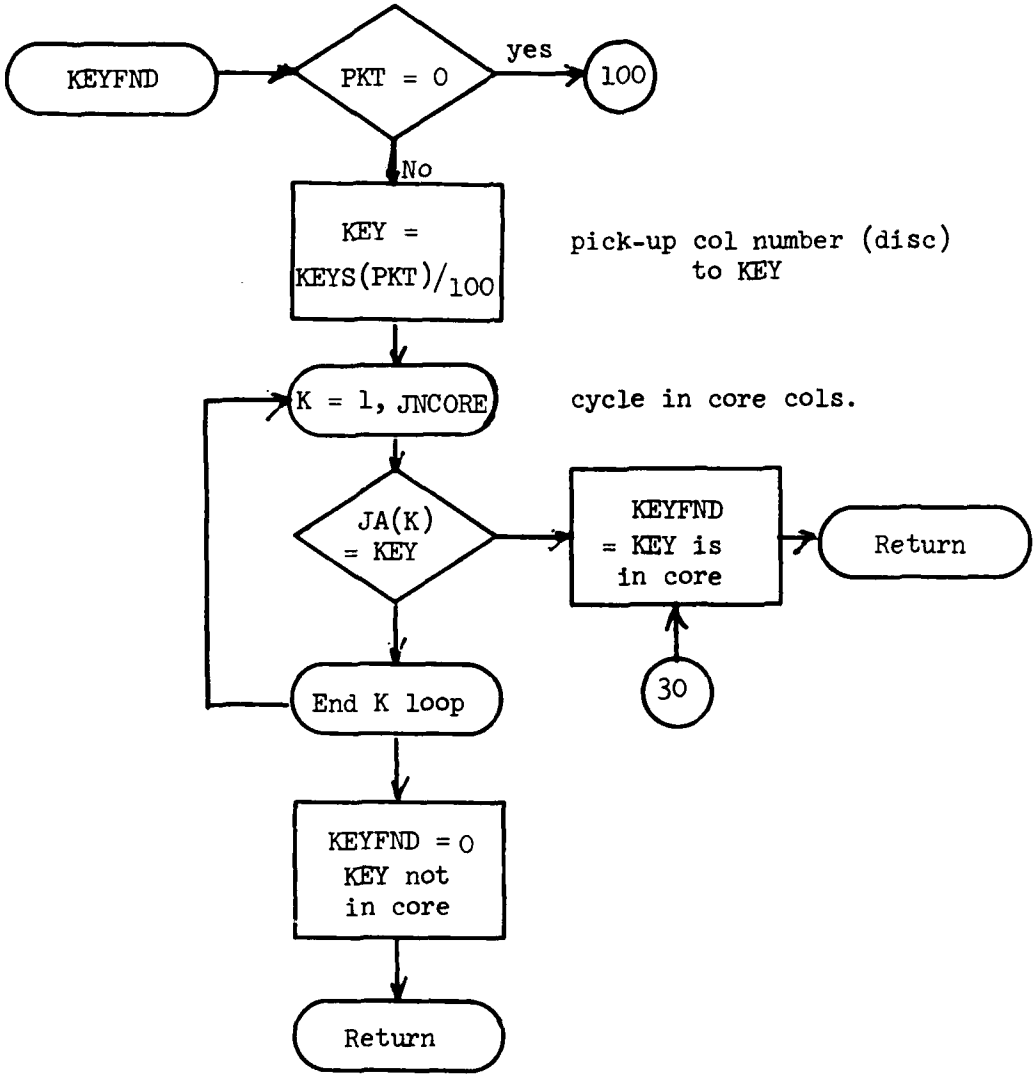


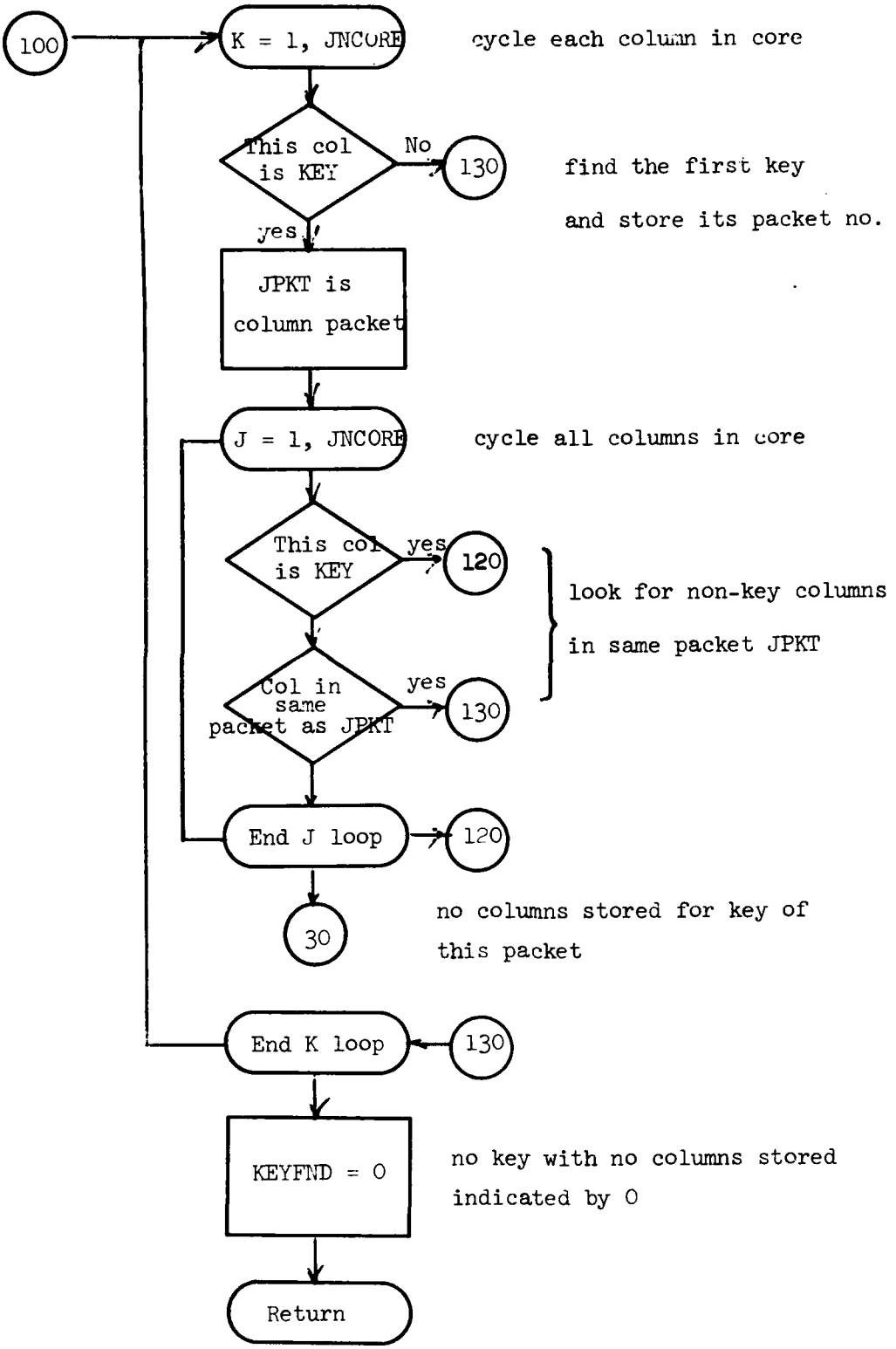
NB. NAME format has least significant decimal digits as shown.

```
.......O O B B K K K K S
bound index | GUB | state
   or O     | packet |
```

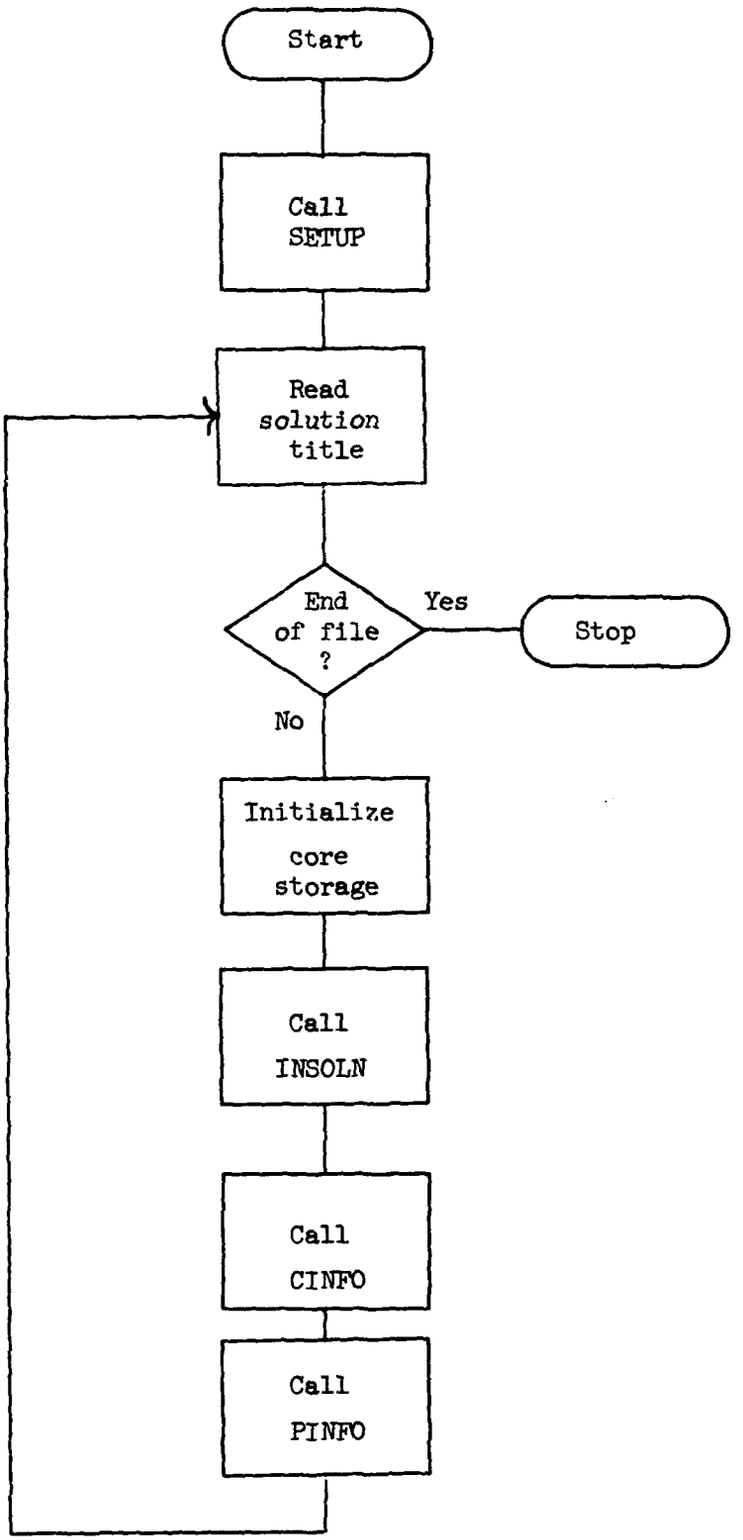
Function KEYFND

KEYFND finds key column of a packet in core or returns 0.

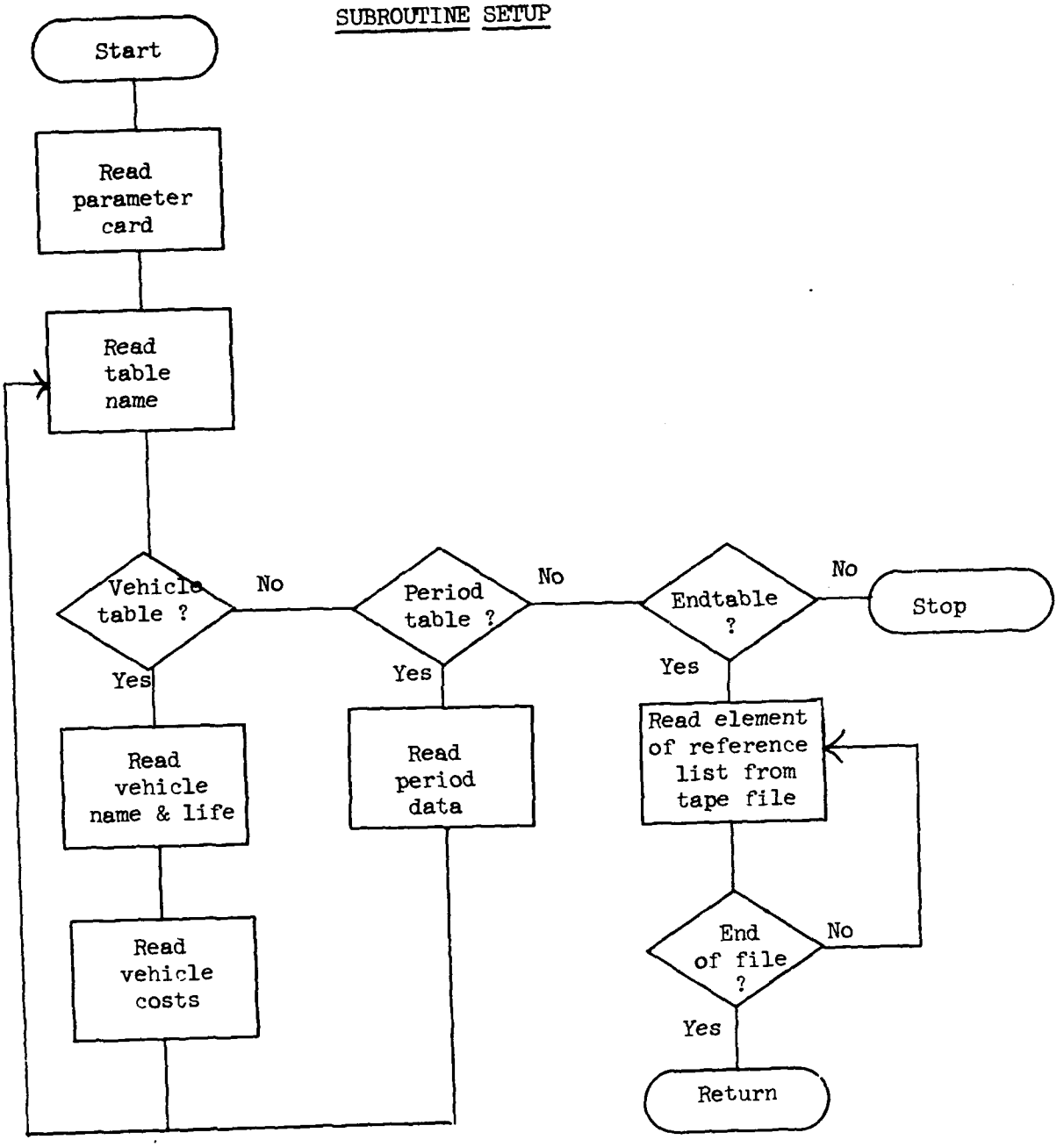



100
K = 1, JNCORE
cycle each column in core
This col is KEY
No
130
find the first key
and store its packet no.
yes
JPKT is column packet
J = 1, JNCORE
cycle all columns in core
This col is KEY
yes
120
look for non-key columns
in same packet JPKT
Col in same packet as JPKT
yes
130
End J loop
120
30
no columns stored for key of this packet
End K loop
130
KEYFND = 0
no key with no columns stored indicated by 0
Return

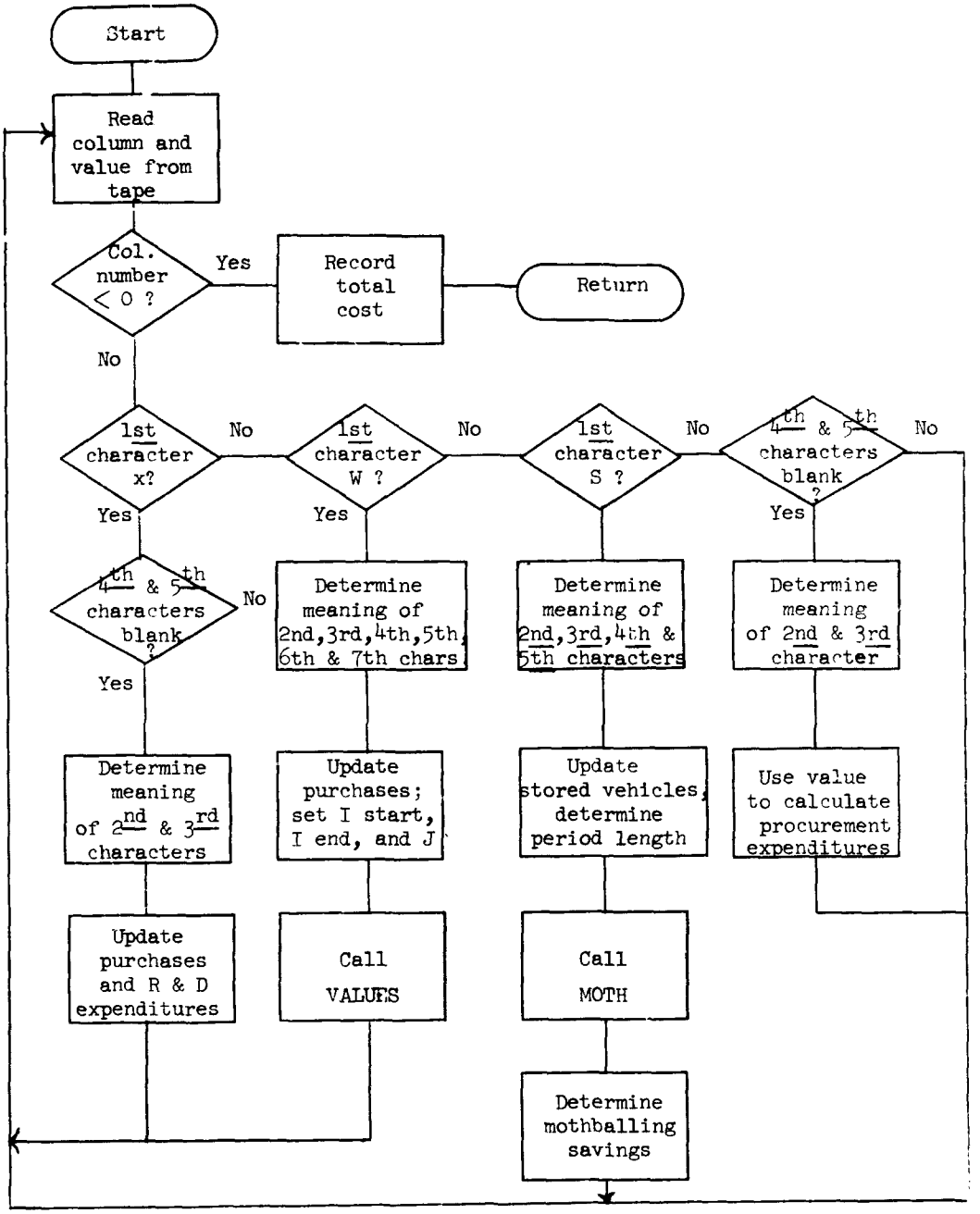
PROGRAM REPGEN



SUBROUTINE SETUP

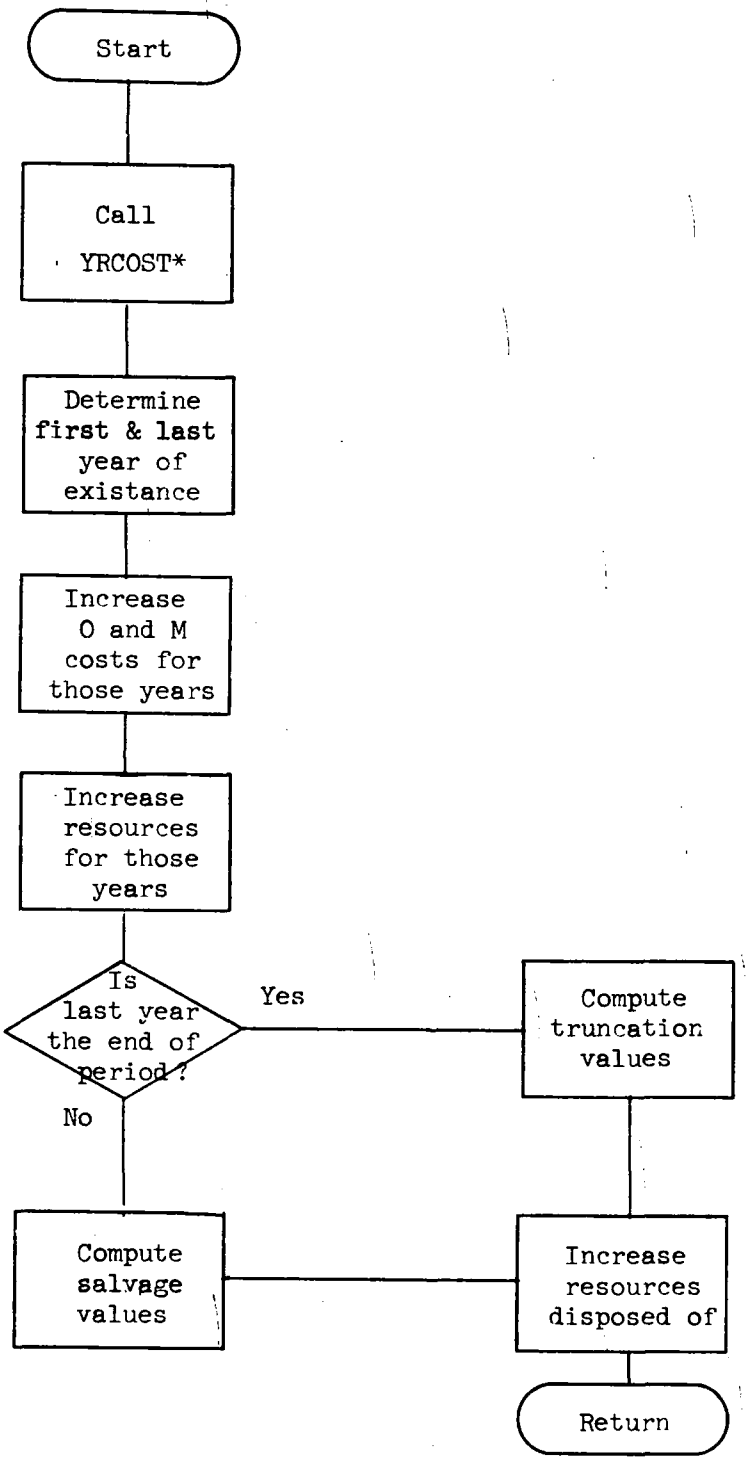


SUBROUTINE INSOLN



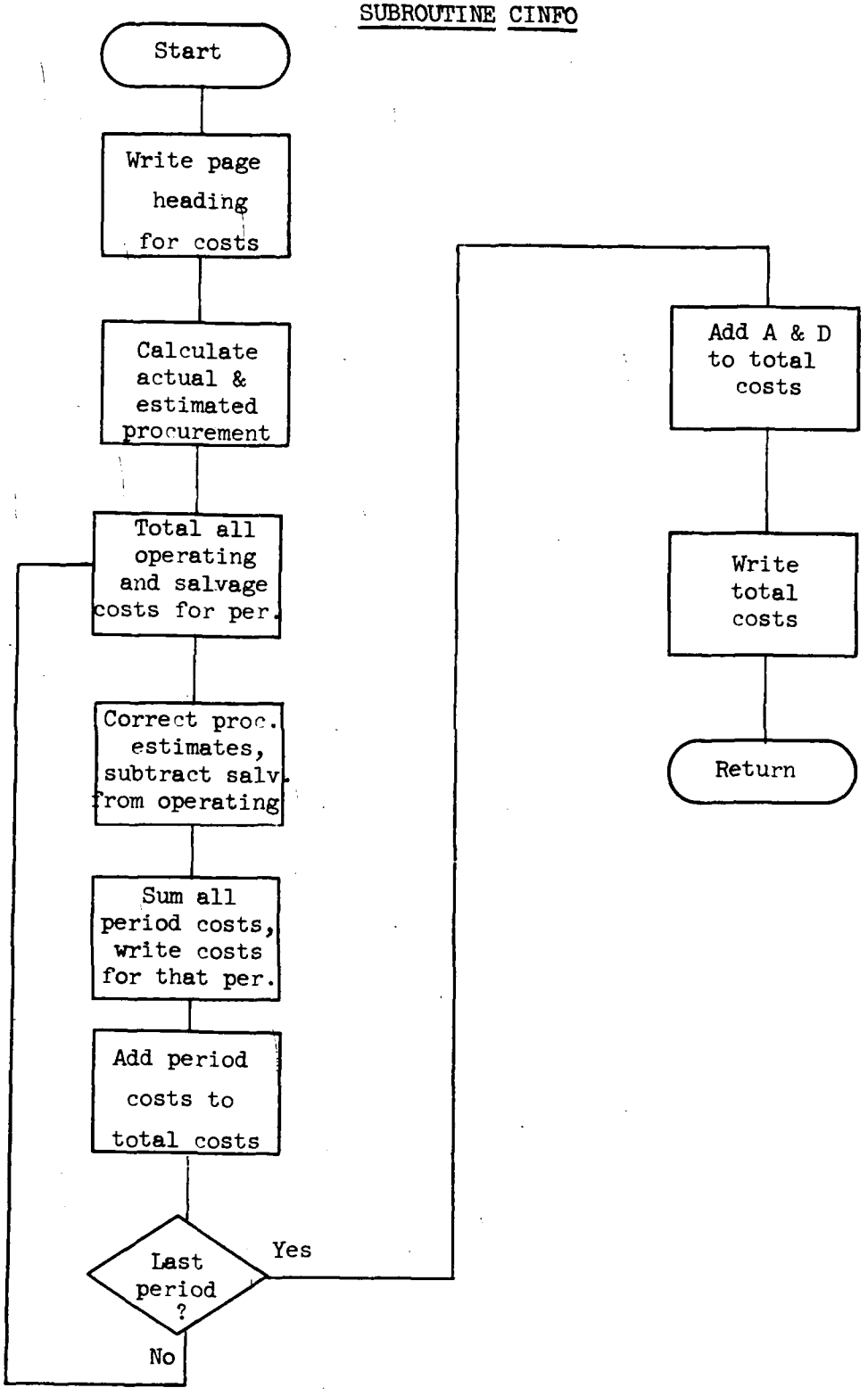
450 CONTINUE

SUBROUTINE VALUES

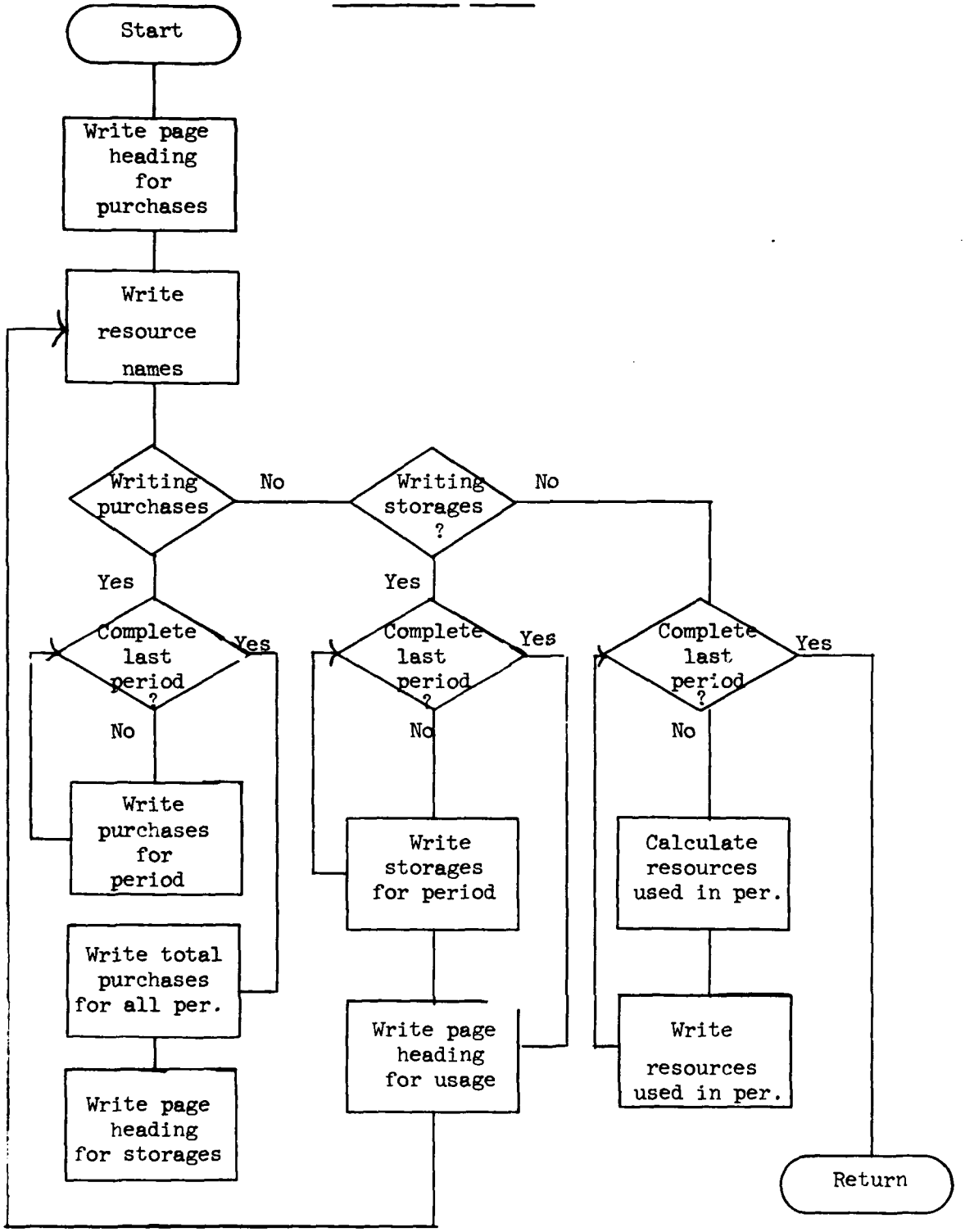


* This is the same routine as used in the matrix generator; its documentation is found there.

SUBROUTINE CINFO



SUBROUTINE PINFO



APPENDIX D

PROGRAM LISTING

```
      PROGRAM GENLCP(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE4,TAPE9,  10000010
     *TAPE7)                                                              10000020
C THIS PROGRAM GENERATES THE MATRIX FILE FOR THE LEAST COST PHASE-IN      10000030
C PROBLEM.                                                               10000040
C                                                                        10000050
C  THE DIMENSIONS HAVE BEEN SET TO HANDLE                                10000060
C   MAXIMUM NUMBER OF VEHICLES          =7                               10000070
C   MAXIMUM VEHICLE LIFE    (IN YEARS) =25                               10000080
C   MAXIMUM NUMBER OF YEARS PRIOR TO SY=16                               10000090
C   MAXIMUM NUMBER OF TASK TABLES       =8                               10000100
C   MAXIMUM NUMBER OF ALTERNATIVES      =288                             10000110
      COMMON /VECSTG/ VNAME(10), C,LENP, VLIFE(10), INH(10,16),          10000120
     * VCOST(10,5), NAMEN(10), COSTS(3:,3)                               10000130
      COMMON / ALTSTG / ALTER(288,9),YAVL(10)                            10000140
      INTEGER ALTER                                                      10000150
      INTEGER ENAME, SY,LY,VNAME,YAVL,VLIFE,YEAR(21)                     10000160
      DIMENSION BUDG(10)                                                 10000170
      DIMENSION NVEHU(20),NL(10),NN(10)                                  10000180
      DIMENSION NAMES(10), AU(16), UB(10),YRINT(20)                      10000190
      COMMON /TSKSTG/ U(7,288,9) ,NTSK( 9)                               10000200
      COMMON /PRDSTG/ NPERYR(10,3), NPTASK(10, 9), PTASK(10,9)           10000210
      DIMENSION IHVN(10)                                                 10000220
      DIMENSION NP(288),NM(9),NPM(10)                                    10000230
C                                                                        10000240
      DATA(NP(I),I=1,240)/2H01,2H02,2H03,2H04,2H05,2H06,2H07,2H08,2H09,  10000250
     *2H10,2H11,2H12,2H13,2H14,2H15,2H16,2H17,2H18,2H19,2H20,2H21,2H22,  10000260
     *2H23,2H24,2H25,2H26,2H27,2H28,2H29,2H3C,2H31,2H32,2H33,2H34,2H35,  10000270
     * 2H36,2H37,2H38,2H39,2H40,2H41,2H42,2H43,2H44,2H45,2H46,2H47,2H48,  10000280
     * 2H49,2H50,2H51,2H52,2H53,2H54,2H55,2H56,2H57,2H58,2H59,2H61,       10000290
     * 2H61,2H62,2H63,2H64,2H65,2H66,2H67,2H68,2H69,2H70,2H71,2H72,       10000300
     * 2H73,2H74,2H75,2H76,2H77,2H78,2H79,2H80,2H81,2H82,2H83,2H84,       10000310
     * 2H85,2H86,2H87,2H88,2H89,2H90,2H91,2H92,2H93,2H94,2H95,2H96,       10000320
     * 2H97,2H98,2H99,2HA0,2HA1,2HA2,2HA3,2HA4,2HA5,2HA6,2HA7,2HA8,       10000330
     * 2HA9,2HB0,2HB1,2HB2,2HB3,2HB4,2HB5,2HB6,2HB7,2HB8,2HB9,2HC0,       10000340
     * 2HC1,2HC2,2HC3,2HC4,2HC5,2HC6,2HC7,2HC8,2HC9,2HD0,2HD1,2HD2,       10000350
     * 2HD3,2HD4,2HD5,2HD6,2HD7,2HD8,2HD9,2HE0,2HE1,2HE2,2HE3,2HE4,       10000360
     * 2HE5,2HE6,2HE7,2HE8,2HE9,2HF0,2HF1,2HF2,2HF3,2HF4,2HE5,2HF6,       10000370
     * 2HF7,2HF8,2HF9,2HG0,2HG1,2HG2,2HG3,2HG4,2HG5,2HG6,2HG7,2HG8,       10000380
     * 2HG9,2HH0,2HH1,2HH2,2HH3,2HH4,2HH5,2HH6,2HH7,2HH8,2HH9,2HJ0,       10000390
     * 2HJ1,2HJ2,2HJ3,2HJ4,2HJ5,2HJ6,2HJ7,2HJ8,2HJ9,2HK0,2HK1,2HK2,       10000400
     * 2HK3,2HK4,2HK5,2HK6,2HK7,2HK8,2HK9,2HL0,2HL1,2HL2,2HL3,2HL4,       10000410
     * 2HL5,2HL6,2HL7,2HL8,2HL9,2HM0,2HM1,2HM2,2HM3,2HM4,2HM5,2HM6,       10000420
     * 2HM7,2HM8,2HM9,2HN0,2HN1,2HN2,2HN3,2HN4,2HN5,2HN6,2HN7,2HN8,       10000430
     * 2HN9,2HP0,2HP1,2HP2,2HP3,2HP4,2HP5,2HP6,2HP7,2HP8,2HP9,2HQ0/       10000440
      DATA(NP(I),I=241,288)/2HQ1,2HQ2,2HQ3,2HQ4,2HQ5,2HQ6,2HQ7,2HQ8,     10000450
     *2HQ9,2HR0,2HR1,2HR2,2HR3,2HR4,2HR5,2HR6,2HR7,2HR8,2HR9,2HT0,2HT1,  10000460
     *2HT2,2HT3,2HT4,2HT5,2HT6,2HT7,2HT8,2HT9,2HU0,2HU1,2HU2,2HU3,2HU4,  10000470
     *2HU5,2HU6,2HU7,2HU8,2HU9,2HW0,2HW1,2HW2,2HW3,2HW4,2HW5,2HW6,       10000480
     *2HW7,2HW8/                                                         10000490
      DATA NM/2HM1,2HM2,2HM3,2HM4,2HM5,2HM6,2HM7,2HM8,2HM9/              10000500
      DATA NZ/2H00/                                                      10000510
      DATA SX,SW,SP,SS,SR,SG/1HX,1HW,1HP,1HS,1HB,1HG/                    10000520
      DATA IVT,ITT,IPT,IED /8HVEHICLE  ,8HTASK    ,8HPERIOD  ,           10000530
     * 8HENDTABLE /                                                      10000540
      ONE=1.0                                                            10000550
      ONEM=-1.0                                                          10000560
C                                                                        10000570
```

```
      DO 3 I=1,7                                                        10000580
      DO 2 J=1,288                                                      10000590
      DO 1 K=1,9                                                        10000600
      U(I,J,K)=0.0                                                      10000610
    1 CONTINUE                                                          10000620
    2 CONTINUE                                                          10000630
    3 CONTINUE                                                          10000640
C THE FIRST DATA CARD CONTAINS 1A. THE FILENAME TO BE USED =FNAME       10000650
C                              1B. THE STARTING YEAR (OR DECISION YEAR) 10000660
C                              1C. THE LAST YEAR = LY              =SY  10000670
C                              2A. THE NUMBER OF VEHICLES = NV          10000680
C                              2B. THE NUMBER OF TASKS    = NT          10000690
C                              2C. THE NUMBER OF PERIODS  = NPP         10000700
C                              3A. -P(L-1) PARAMETER                    10000710
      READ(5,1000) FNAME, SY,LY, NV,NT,NPP,I7PLM1                       10000720
 1000 FORMAT(A8,2X,6I5)                                                 10000730
      WRITE(6,1010)FNAME, SY,LY, NV,NT,NPP                              10000740
 1010 FORMAT(5CH1 GENERATING THE MATRIX FOR THE LEAST COST PHASE-IN PROB10000750
     *LEM  /11HOFILENAME= ,A8,15H STARTING YEAR =,I5,12H LAST YEAR =,I5,10000760
     */11H WILL INPUT,I3,2CH VEHICLE TABLES, AND, I3,1EH TASK TABLE, AND10000770
     *, I3,15H PERIOD TABLES. )                                         10000780
      NVP=0                                                             10000790
      NTP=0                                                             10000800
      NPT=0                                                             10000810
      NIV=0                                                             10000820
      NINHP=0                                                           10000830
C  READ TITLE OF NEXT TABLE                                             10000840
   10 READ(5,1000) ITABLE                                               10000850
C  DECODE THE TYPE OF TABLE AND GO READ ITS DATA                        10000860
      IF(ITABLE .EQ. IVT) GO TO 20                                      10000870
   11 IF(ITABLE .EQ. ITT) GO TO 40                                      10000880
      IF(ITABLE .EQ. IPT) GO TO 60                                      10000890
      IF(ITABLE .EQ. IED) GO TO 100                                     10000900
C  THE TABLE NAME IS NOT RECOGNIZED, THERE IS AN INPUT ERROR            10000910
      WRITE(6,1020) ITABLE                                              10000920
 1020 FORMAT(1X,A8,60H IS NOT A TABLE NAME, INPUT ERROR. EXECUTION IS TE10000930
     *RMINATED.     )                                                  10000940
      STOP 1                                                            10000950
   20 WRITE(6,1030)                                                     10000960
 1030 FORMAT( 30HC READING IN A VEHICLE TABLE     )                     10000970
      NVP=NVP+1                                                         10000980
      READ(5,1040) VNAME(NVP), YAVL(NVP), VLIFE(NVP)                    10000990
      WRITE(6,1050)VNAME(NVP), YAVL(NVP), VLIFE(NVP)                    10001000
 1040 FORMAT(A8,1X,I4,6X,I2)                                            10001010
 1050 FORMAT(1X,A8,2X,2I10)                                             10001020
C VNAME=NAME OF VEHICLE, YAVL= 1ST YEAR VEHICLE AVALIBLE,               10001030
C VLIFE= MAXIMUM LIFE OF VEHICLE IN YEARS.                              10001040
C                                                                       10001050
C IF THIS VEHICLE WAS AVALIABLE BEFORE THE STARTING YEAR, THEN READ IN  10001060
C SIZE OF INHERITED FLEET, BY YEAR BUILT.                               10001070
      NU=SY - YAVL(NVP)                                                 10001080
      IF( NU) .LE. 0) GO TO 25                                          10001090
      NIV=NIV+1                                                         10001100
      IA=1                                                              10001110
      IB=9                                                              10001120
   23 READ(5,1060)(INH(NVP,I),I=IA,IB)                                  10001130
 1060 FORMAT(8I1))                                                      10001140
      IF(IB .GE. NU) GO TO 25                                           10001150
```

```
      IA=IB+1                                                          10001160
      IB=IB+8                                                          10001170
      GO TO 23                                                         10001180
   25 READ (5,1070) (VCOST(NVR,I),I=1,5)                               10001190
 1070 FORMAT (5F10.2)                                                  10001200
C  VCOST(NVR,1) .GT. 1.0E30 INDICATES THIS VEHICLE IS NOT AVALIABLE FOR 10001210
C  PURCHASE.                                                           10001220
      GO TO 10                                                         10001230
C                                                                      10001240
C  IT IS ASSUMED THAT ALL VEHICLE TABLES ARE INPUTED FIRST.            10001250
   40 WRITE(6,1080)                                                    10001260
 1080 FORMAT(25H0 READING IN A TASK TABLE  )                           10001270
      NTR=NTR+1                                                        10001280
      READ(5,1090)  IDT,NU,NA                                          10001290
      WRITE(6,1090) IDT,NU,NA                                          10001300
 1090 FORMAT(3I10)                                                     10001310
C  IDT=TASK IDENTIFICATION NUMBER, NU=NUMBER OF VEHICLES,              10001320
C  NA=NUMBER OF ALTERNATIVES                                           10001330
      NTSK(IDT)=NA                                                     10001340
      IA=1                                                             10001350
      IB=8                                                             10001360
   43 READ(5,1100) (NAMES(I),I=IA,IB)                                  10001370
 1100 FORMAT(8(A8,2X))                                                 10001380
      IF(IB .GE. NU) GO TO 45                                          10001390
      IA=IB+1                                                          10001400
      IB=IB+8                                                          10001410
      GO TO 43                                                         10001420
   45 DO 47 I=1,NU                                                     10001430
      DO 46 J=1,NVR                                                    10001440
      IF(VNAME(J) .NE. NAMES(I)) GO TO 46                              10001450
      NAMES(I)=J                                                       10001460
      GO TO 47                                                         10001470
   46 CONTINUE                                                         10001480
      WRITE(6,1110) NAMES(I)                                           10001490
 1110 FORMAT(1540 VEHICLE NAME ,A8,60H NOT DEFINED IN A VEHICLE TABLE, E10001500
     *XECUTION TERMINATED.          )                                  10001510
      STOP 2                                                           10001520
   47 CONTINUE                                                         10001530
C                                                                      10001540
C  NOW READ IN U(J,K,L), NUMBER OF VEHICLES OF TYPE J REQUIRED TO      10001550
C  PERFORM TASK L WITH ALTERNATIVE K.                                  10001560
      DO 55 K=1,NA                                                     10001570
      IA=1                                                             10001580
      IB=8                                                             10001590
   48 READ(5,1120) (AU(I),I=IA,IB)                                     10001600
 1120 FORMAT(8F10.0)                                                   10001610
      IF(IB .GE. NU) GO TO 49                                          10001620
      IA=IB+1                                                          10001630
      IB=IB+8                                                          10001640
      GO TO 43                                                         10001650
   49 DO 50 I=1,NU                                                     10001660
      J=NAMES(I)                                                       10001670
      U(J,K,IDT)=AU(I)                                                 10001680
   50 CONTINUE                                                         10001690
   55 CONTINUE                                                         10001700
   56 READ(5,1000) ITABLE                                              10001710
      GO TO 11                                                         10001720
C                                                                      10001730
```

```
   60 WRITE(6,1130)                                                      10001740
 1130 FORMAT(30H0 READING IN A PERIOD TABLE     )                        10001750
C  THE PERIOD TABLES ARE EXPECTED IN CHRONOLOGICAL ORDER.               10001760
      NPT=NPT+1                                                         10001770
      READ (5,1140) (NPERYR(NPT,I),I=1,2),RUDG(NPT)                     10001780
 1140 FORMAT (I4,I5,3X,F8.2)                                            10001790
      WRITE(6,1150)(NPERYR(NPT,I),I=1,2)                                10001800
 1150 FORMAT(2I5)                                                       10001810
      IF(NPT .EQ. 1) GO TO 61                                           10001820
      IF(NPERYR(NPT-1,2)+1 .EQ. NPERYR(NPT,1) ) GO TO 61                10001830
      WRITE(6,1155)                                                     10001840
 1155 FORMAT(35H THE PERIOD TABLES ARE OUT OF ORDER )                   10001850
      STOP 3                                                            10001860
   61 IF(SY .GT. NPERYR(NPT,1) ) GO TO 70                               10001870
      READ(5,1158) NU,YRINT(NPT)                                        10001880
 1158 FORMAT (I10,F10.3)                                                10001890
C  ALL THE TASKS ARE SCALED BY THE FACTOR YRINT(NPT) IN THE  PERIOD NPT 10001900
      NPERYR(NPT,3)=NU                                                  10001910
      IA=1                                                              10001920
      IB=8                                                              10001930
      NA=NPT-NINHP                                                      10001940
   62 READ(5,1160)((NPTASK(NA,I), PTASK(NA,I)),I=IA,IB)                 10001950
 1160 FORMAT(8(I5,F5.0))                                                10001960
      IF(IB .GE. NU) GO TO 56                                           10001970
      IA=IB+1                                                           10001980
      IB=IB+8                                                           10001990
      GO TO 62                                                          10002000
   70 NINHP=NINHP+1                                                     10002010
      GO TO 56                                                          10002020
C                                                                       10002030
C  ALL TABLE HAVE BEEN READ IN. NOW PROCESS THEM TO BE ABLE TO GENERATE 10002040
C  THE MATRIX.                                                          10002050
C  FIRST CHECK TO DETERMINE IF THE EXPECTED NUMBER OF TABLE WERE INPUTED10002060
  100 IF((NV .EQ. NVP) .AND. (NT .EQ. NTP) .AND. (NPP.EQ. NPT))GO TO 105 10002070
      WRITE(6,1170)                                                     10002080
 1170 FORMAT(71H WARNING-THE NUMBER OF TABLE ACTUALLY INPUT WAS NOT THE 10002090
     *EXPECT NUMBER.    )                                              10002100
C                                                                       10002110
C  ORDER THE VECHILES SO THE ARE IN DECENDING ORDER OF R+D COST.        10002120
  105 NRD=0                                                             10002130
      DO 107 I=1,NVP                                                    10002140
      NAMEN(I)=I                                                        10002150
      IF(VCOST(I,3) .LE. 0.0) GO TO 107                                 10002160
      NRD=NRD+1                                                         10002170
  107 CONTINUE                                                          10002180
      IF(NRD.EQ.0) GO TO 151                                            10002190
      NV=NVP-1                                                          10002200
      DO 120 II=1,NV                                                    10002210
      I=NAMEN(II)                                                       10002220
      IMAX=II                                                           10002230
      IP1=II+1                                                          10002240
      CMAX=VCOST(I,3)                                                   10002250
      DO 110 JJ=IP1,NVP                                                 10002260
      J=NAMEN(JJ)                                                       10002270
      IF(CMAX .GE. VCOST(J,3))GO TO 110                                 10002280
      IMAX=JJ                                                           10002290
      CMAX=VCOST(J,3)                                                   10002300
  110 CONTINUE                                                          10002310
```

```
      J=NAMEN(TMAX)                                                     10002320
      NAMEN(IMAX)=NAMEN(II)                                             10002330
      NAMEN(II)=J                                                       10002340
      IF(VCOST(J,3) .GT. 0.0) GO TO 125                                 10002350
      GO TO 125                                                         10002360
  120 CONTINUE                                                          10002370
C                                                                       10002380
C NOW DETERMINE IF FOR ANY R+D VEHICLE ITS DEVELOPMENT IS NOT OPTIONAL. 10002390
C  IT IS ASSUMED ALL TASKS ARE PREFORMED DURING SOME PERIOD AND         10002400
C  THE TASKS HAVE BEEN NUMBERED SEQUENTIALLY.                           10002410
  125 DO 140 I=1,NRD                                                    10002420
      NAMES(I)=1                                                        10002430
      J=NAMEN(I)                                                        10002440
      DO 133 L=1,NTR                                                    10002450
      NA=NTSK(L)                                                        10002460
      DO 130 K=1,NA                                                     10002470
      IF(U(J,K,L) .EQ. 0.0) GO TO 133                                   10002480
  130 CONTINUE                                                          10002490
C  FOUND A TASK REQUIRING THAT VEHICLE J BE DEVELOPED                   10002500
      NAMES(I)=2                                                        10002510
      GO TO 140                                                         10002520
  133 CONTINUE                                                          10002530
  140 CONTINUE                                                          10002540
C  NAMES(I)=2 IF THE I TH MOST EXPENSIVE R+D COSTING VEHICLE MUST BE    10002550
C  DEVELOPED, =1 OTHERWISE                                              10002560
C  IF A VEHICLE MUST BE DEVELOPED TREAT IT AS IF ITS R+D COST =0        10002570
      NA=0                                                              10002580
      DO 145 I=1,NRD                                                    10002590
      K=NAMES(I)                                                        10002600
      GO TO (145,143),K                                                 10002610
  143 L=NAMEN(I)                                                        10002620
      IP1=I+1                                                           10002630
      K=NRD-NA                                                          10002640
      DO 144 II=IP1,K                                                   10002650
  144 NAMEN(II-1)=NAMEN(II)                                             10002660
      NAMEN(K)=L                                                        10002670
      NA=NA+1                                                           10002680
  145 CONTINUE                                                          10002690
      NRD=NRD-NA                                                        10002700
C  LIST VECHILE NAMES AND CORRESPONDING VARABLE LABELS.                 10002710
      WRITE(6,1180)                                                     10002720
 1180 FORMAT(33H0   VEHICLE NAME    VARIABLE NAME /  8X,                10002730
     *                  21HOPTIONAL R+D VEHICLES  )                    10002740
      DO 150 II=1,NRD                                                   10002750
      I=NAMEN(II)                                                       10002760
      WRITE(6,1190) VNAME(I), NP(II)                                    10002770
 1190 FORMAT(6X, A8, 5X, 1HX,A2)                                        10002780
  150 CONTINUE                                                          10002790
      IF(NVR .LE. NRD) GO TO  200                                       10002800
  151 WRITE(6,1200)                                                     10002810
 1200 FORMAT(13X,14HOTHER VEHICLES )                                    10002820
      J=NRD+1                                                           10002830
      DO 155 II=J,NVR                                                   10002840
      I=NAMEN(II)                                                       10002850
      WRITE(6,1190) VNAME(I), NP(II)                                    10002860
  155 CONTINUE                                                          10002870
C                                                                       10002880
      NROW=0                                                            10002890
```

```
      NCOL=0                                                            10002900
C LIST ROW NAMES                                                        10002910
  200 WRITE(6,1210) ENAME                                               10002920
 1210 FORMAT(2H *, 4HNAME,11X,A8/ 2H *,4HROWS)                          10002930
      WRITE(4,1211) ENAME                                               10002940
 1211 FORMAT     ( 4HNAME,11X,A8/ 4HROWS)                               10002950
C                                                                       10002960
C                                                                       10002970
C  NOW THE ROW LABELS FOR THE MASTER VARIABLES                          10002980
      DO 220 I=1,NVP                                                    10002990
      WRITE(6,1240) NP(I)                                               10003000
 1240 FORMAT(2H *, 8H E  SUMX,A2)                                       10003010
      WRITE(4,1241) NP(I)                                               10003020
      NROW=NROW+1                                                       10003030
 1241 FORMAT     ( 8H E  SUMX,A2)                                       10003040
  220 CONTINUE                                                          10003050
C                                                                       10003060
C           ROWS FOR PROCUREMENT CONSTRAINTS                            10003070
C                                                                       10003080
      IA=NPT-NINHP                                                      10003090
      DO 225 I=1,IA                                                     10003100
      WRITE (4,1225) NP(I)                                              10003110
 1225 FORMAT (6H E  PC,A2)                                              10003120
      WRITE (6,1224) NP(I)                                              10003130
 1224 FORMAT (2H *,6H E  PC,A2)                                         10003140
      NROW=NROW+1                                                       10003150
  225 CONTINUE                                                          10003160
C                                                                       10003170
C  NOW THE ROWS ACCOUNTING FOR THE INHERITED FLEET.                     10003180
      IF(NINHP .EQ. 0) GO TO 300                                        10003190
      IB=NINHP - 1                                                      10003200
      IF(IB .EQ. 0) GO TO 240                                           10003210
      DO 230 I=1,IB                                                     10003220
      J=NINHP - I                                                       10003230
      NPM(I)=NM(J)                                                      10003240
  230 CONTINUE                                                          10003250
  240 NPM(NINHP) =NZ                                                    10003260
      IF(NTV .EQ. 0) GO TO 300                                          10003270
      NA=NPD + 1                                                        10003280
      JC=1                                                              10003290
      DO 260 JJ=NA,NVP                                                  10003300
      J=NAMEN(JJ)                                                       10003310
      IF(YAVL(J) .GE. SY) GO TO 260                                     10003320
      THVN(JC)=JJ                                                       10003330
      JC=JC+1                                                           10003340
      DO 250 I=1,NINHP                                                  10003350
      IF(YAVL(J) .GT. NPERYP(I,2)) GO TO 250                            10003360
      IA=MAXO(YAVL(J),NPERYP(I,1)) - YAVL(J) + 1                        10003370
      IB=NPERYP(I,2) - YAVL(J) + 1                                      10003380
      DO 245 K=IA,IB                                                    10003390
      IF(INH(J,K) .GT. 0) GO TO 249                                     10003400
  245 CONTINUE                                                          10003410
      GO TO 250                                                         10003420
  249 WRITE(6,1250) NP(JJ),NPM(I)                                       10003430
 1250 FORMAT(2H *, 6H E  IW,A2,1HP,A2)                                  10003440
      WRITE(4,1251) NP(JJ),NPM(I)                                       10003450
      NROW=NROW+1                                                       10003460
 1251 FORMAT     ( 6H E  IW,A2,1HP,A2)                                  10003470
```

```
  250 CONTINUE                                                          10003480
  260 CONTINUE                                                          10003490
C                                                                       10003500
C  NOW PUT OUT THE LABELS FOR THE ROWS FOR EACH PERIOD, THE VEHICLE     10003510
C  BALANCE ROWS FIRST, THEN THE TASK ROWS.                              10003520
  300 IA=NINHP + 1                                                      10003530
      DO 350 I=IA,NPT                                                   10003540
      IB=I - NINHP                                                      10003550
      NU=NPERYR(I,3)                                                    10003560
      DO 340 JJ=1,NVR                                                   10003570
C  IF THE VEHICLE IS NOT YET AVALIABLE IT CAN NOT BE USED.              10003590
      J=NAMEN(JJ)                                                       10003580
      IF(YAVL(J) .GT. NPERYR(I,2)) GO TO 340                            10003600
C  MAKE SURE THE VEHICLE IS USED                                        10003610
      DO 320 K=1,NU                                                     10003620
      KT=NPTASK(IB,K)                                                   10003630
      NA=NTSK(KT)                                                       10003640
      DO 310 K2=1,NA                                                    10003650
      IF(U(J,K2,KT) .NE. 0.0) GO TO 330                                 10003660
  310 CONTINUE                                                          10003670
  320 CONTINUE                                                          10003680
      GO TO 340                                                         10003690
  330 WRITE(6,1260) NP(JJ), NP(IB)                                      10003700
 1260 FORMAT(2H *,5H E  X,A2,1HP,A2)                                    10003710
      WRITE(4,1261) NP(JJ), NP(IB)                                      10003720
      NROW=NROW+1                                                       10003730
 1261 FORMAT     (5H E  X,A2,1HP,A2)                                    10003740
  340 CONTINUE                                                          10003750
      DO 345 K=1,NU                                                     10003760
      KT=NPTASK(IB,K)                                                   10003770
      WRITE(6,1270) NP(KT), NP(IB)                                      10003780
 1270 FORMAT(2H *, 5H E  T,A2,1HP,A2)                                   10003790
      WRITE(4,1271) NP(KT), NP(IB)                                      10003800
      NROW=NROW+1                                                       10003810
 1271 FORMAT     ( 5H E  T,A2,1HP,A2)                                   10003820
  345 CONTINUE                                                          10003830
  350 CONTINUE                                                          10003840
C                                                                       10003850
C  COMPUTE UPPER BOUNDS                                                 10003860
      DO 390 II=1,NVR                                                   10003870
      UB(II)=0.0                                                        10003880
      I2=NAMEN(II)                                                      10003890
      IA=NINHP+1                                                        10003900
      DO 390 I=IA,NPT                                                   10003910
      NU=NPERYR(I,3)                                                    10003920
      I1=I - NINHP                                                      10003930
      IF (YAVL(I2).GT.NPERYR(I,2)) GO TO 380                            10003940
      DO 375 J=1,NU                                                     10003950
      JJ=NPTASK(I1,J)                                                   10003960
      TF= PTASK(I1,J)                                                   10003970
      NA=NTSK(JJ)                                                       10003980
      UMAX=0.0                                                          10003990
      DO 370 K=1,NA                                                     10004000
      IF(UMAX .GT. U(I2,K,JJ) ) GO TO 370                               10004010
      UMAX=U(I2,K,JJ)                                                   10004020
  370 CONTINUE                                                          10004030
      UB(II)=UB(II) - TF*UMAX*YRINT(I)                                  10004040
  375 CONTINUE                                                          10004050
```

```
  380 CONTINUE                                                          10004160
  390 CONTINUE                                                          10004170
      WRITE(6,1220)                                                     10004180
 1220 FORMAT(2H *,8H N  COST)                                           10004190
      WRITE(4,1221)                                                     10004200
      MROW=MROW+1                                                       10004210
 1221 FORMAT     (8H N  COST)                                           10004220
C                                                                       10004230
      WRITE(6,1280)                                                     10004240
 1280 FORMAT(2H *, 7HCOLUMNS)                                           10004250
      WRITE(6,1290)                                                     10004260
 1290 FORMAT(2H *,8X,*(PARTIAL LISTING)*)                               10004270
      WRITE(4,1291)                                                     10004280
 1291 FORMAT     ( 7HCOLUMNS)                                           10004290
C  NOW GENERATE THE MATRIX ELEMENTS.                                    10004300
C                                                                       10004310
C  THE XNN COLUMNS.                                                     10004320
      DO 420 I=1,NVO                                                    10004330
      II=NAMEN(I)                                                       10004340
      WRITE(6,1300) NP(I),NP(I),ONEM                                    10004350
 1300 FORMAT(2H *,4X,1HX,A2,7X,                4HSUMX,A2,4X,F12.4)     10004360
      WRITE(4,1301) NP(I),NP(I),ONEM                                    10004370
      MCOL=MCOL+1                                                       10004380
 1301 FORMAT     (4X,1HX,A2,7X,                4HSUMX,A2,4X,F12.4)     10004390
  420 CONTINUE                                                          10004400
C                                                                       10004310
C       THE 2NN COLUMNS                                                 10004320
C                                                                       10004330
      IA=NPT-NTNHP                                                      10004340
      DO 430 I=1,IA                                                     10004350
      WRITE (4,1311) NP(I),NP(I),ONE                                    10004360
 1311 FORMAT (4X,1HP,A2,7X,2HPC,A2,6X,F12.4)                            10004370
      WRITE (6,1310) NP(I),NP(I),ONE                                    10004380
 1310 FORMAT (2H *,4X, 1HP,A2,7X,2HPC,A2,6X,F12.4)                      10004390
      MCOL=MCOL+1                                                       10004400
      IF (I.EQ.IA) GO TO 430                                            10004410
       IF(IZPLM1.EQ.1) GO TO 430                                        10004420
      WRITE (4,1313) NP(I),NP(I+1),ONEM                                 10004430
      WRITE (6,1312) NP(I),NP(I+1),ONEM                                 10004440
 1312 FORMAT (2H *,4X,1HP,A2,7X,2HPC,A2,6X,F12.4)                       10004450
 1313 FORMAT      (4X,1HP,A2,7X,2HPC,A2,6X,F12.4)                       10004460
  430 CONTINUE                                                          10004470
C                                                                       10004480
C  GENERATE THE WJJLLMM COLUMNS                                         10004490
C                                                                       10004500
  440 IF(NTV .EQ. 0) GO TO 480                                          10004510
      DO 470 II=1,NTV                                                   10004520
      JJ=IHVN(II)                                                       10004530
      J=NAMEN(JJ)                                                       10004540
      CALL YRCOST(J)                                                    10004550
      DO 460 I=1,NTNHP                                                  10004560
      MAXL=VLIFE(J)                                                     10004570
      IF(YAVL(J) .GT. NPERYR(I,2) ) GO TO 460                           10004580
C  IT IS ASSUMED ALL THE VECHILES INHERITED FROM A PERIOD WERE PURCHASED10004590
C  IN THE FIRST YEAR OF THE PERIOD.                                     10004600
      IA=MAX0(YAVL(J),NPERYR(I,1))- YAVL(J) + 1                         10004610
      IB=NPERYR(I,2) - YAVL(J) + 1                                      10004620
      DO 445 K=IA,IB                                                    10004630
```

```
      IF(INH(J,K) .GT. 0) GO TO 448                                    10004640
  445 CONTINUE                                                         10004650
      GO TO 460                                                        10004660
  448 NAGE=SY-NPERYR(I,1)                                              10004670
      C= COSTS(NAGE,2)                                                 10004680
      LIFER=MAXL-NAGE                                                  10004690
      IF(C .EQ. 0.0) GO TO 449                                         10004700
      C=-C                                                             10004710
      WRITE(6,1330) NP(JJ),NPM(I),NZ, C                                10004720
 1330 FORMAT(2H *,4X,1HW,A2,A2,A2,3X,4HCOST,6X,F12.4)                  10004730
      WRITE(4,1331) NP(JJ),NPM(I),NZ, C                                10004740
 1331 FORMAT     (4X,1HW,A2,A2,A2,3X,4HCOST,6X,F12.4)                  10004750
  449 WRITE(6,1340) NP(JJ),NPM(I),NZ, NP(JJ),NPM(I),ONE                10004760
 1340 FORMAT(2H *,4X,1HW,A2,A2,A2, 3X, 2HIW,A2,1HP,A2,3X,F12.4)        10004770
      WRITE(4,1341) NP(JJ),NPM(I),NZ, NP(JJ),NPM(I),ONE                10004780
      MCOL=MCOL+1                                                      10004790
 1341 FORMAT     (4X,1HW,A2,A2,A2, 3X, 2HIW,A2,1HP,A2,3X,F12.4)        10004800
      IA=NINHP+1                                                       10004810
      DO 455 K=IA,NPT                                                  10004820
C  MAKE SURE THE VECHILE IS USED                                       10004830
      KY=K-NINHP                                                       10004840
      NU=NPERYR(K,3)                                                   10004850
      DO 451 KK=1,NU                                                   10004860
      KT=NPTASK(KY,KK)                                                 10004870
      NA=NTSK(KT)                                                      10004880
      DO 450 K2=1,NA                                                   10004890
      IF(U(J,K2,KT) .NE. 0.0) GO TO 4511                               10004900
  450 CONTINUE                                                         10004910
  451 CONTINUE                                                         10004920
      GO TO 455                                                        10004930
 4511 IF(SY+LIFER .LE. NPERYR(K,1)) GO TO 460                          10004940
      IY=NPERYR(K,2)-NPERYR(I,1)+1                                     10004950
      IX=NPERYR(K,2) -SY + 1                                           10004960
      C=-COSTS(IY,2)                                                   10004970
      IF(K .EQ. NPT) C=-COSTS(IY,3)                                    10004980
      DO 452 KK=1,IX                                                   10004990
      KKK=KK+NAGE                                                      10005000
      C= C + COSTS(KKK,1)/VCOST(J,4)**KK                               10005010
  452 CONTINUE                                                         10005020
      WRITE(6,1330) NP(JJ),NPM(I),NP(KY), C                            10005030
      WRITE(4,1331) NP(JJ),NPM(I),NP(KY), C                            10005040
      WRITE(6,1340) NP(JJ),NPM(I),NP(KY), NP(JJ),NPM(I), ONE           10005050
      WRITE(4,1341) NP(JJ),NPM(I),NP(KY), NP(JJ),NPM(I), ONE           10005060
      MCOL=MCOL+1                                                      10005070
      C=1.0                                                            10005080
      ALPHA=VCOST(J,4)                                                 10005090
      LLL3=0                                                           10005100
      DO 4521 L3=IA,K                                                  10005110
      L4=L3 - NINHP                                                    10005120
      C=-C                                                             10005130
      WRITE(6,1350) NP(JJ),NPM(I),NP(KY), NP(JJ),NP(L4), C             10005140
 1350 FORMAT(2H *,4X,1HW,A2,A2,A2,3X, 1HX,A2,1HP,A2,4X,F12.4)          10005150
      WRITE(4,1351) NP(JJ),NPM(I),NP(KY), NP(JJ),NP(L4), C             10005160
 1351 FORMAT     (4X,1HW,A2,A2,A2,3X, 1HX,A2,1HP,A2,4X,F12.4)          10005170
      LLL3=LLL3 + (NPERYP(L3,2)-NPERYP(L3,1) ) + 1                     10005180
      C=ALPHA**LLL3                                                    10005190
 4521 CONTINUE                                                         10005200
  455 CONTINUE                                                         10005210
```

```
  450 CONTINUE                                                          10000220
  470 CONTINUE                                                          10000230
C                                                                       10000240
C  GENERATE THE B, X, AND C COLUMNS FOR EACH PERIOD                     10000250
  480 IA=NINHP + 1                                                      10000260
      DO 610 LL=IA,NPT                                                  10000270
C  IF YPINT(LL) .EQ. 1.0 IT IS ASSUMED ALL THE VEHICLES USED ARE        10000280
C  AVALIABLE.  HENCE NO CHECK IS MADE.                                  10000290
      IF (YPINT(LL).EQ. 1.0 ) GO TO 491                                 10000300
      NVP=NPERYP(LL,2)                                                  10000310
C  THE SUBROUTINE YINTERP SETS THE ARRAY ALTER TO INDICATE THE          10000320
C  ALTERNATIVES THAT ARE NOT AVALIABLE FOR USE IN PERIOD LL.            10000330
C  IF ALTER(K,J)=0 THEN ALTERNATIVE J OF TASK K IS NOT AVALIABLE FOR    10000340
C  USE.                                                                 10000350
      CALL YINTERP (NVP,NTP,NYP)                                        10000360
  491 L=LL-NINHP                                                        10000370
      DO 493 J=1,NVP                                                    10000380
C                                                                       10000400
C  GENERATE THE BIIKKLL COLUMNS                                         10000410
  493 NVEHU(J)=1                                                        10000500
      NU=NPERYP(LL,1)                                                   10000420
      DO 520 II=1,NU                                                    10000430
      ID=NPTASK(L,II)                                                   10000440
      NA=NTSK(ID)                                                       10000450
      KA=0                                                              10000460
      DO 510 KK=1,NA                                                    10000470
      IF (YPINT(LL).EQ. 1.0 ) GO TO 491                                 10000480
      IF (ALTER(KK,ID).EQ. 0) GO TO 510                                 10000490
  491 KA=KA+1                                                           10000500
      DO 500 JJ=1,NVP                                                   10000510
      J=NAMEN(JJ)                                                       10000520
      IF( U(J,KK,ID) .EQ. 0.0) GO TO 500                                10000530
      IF (YAVL(J).GT.NPERYP(LL,2)) GO TO 500                            10000540
      NVEHU(JJ)=2                                                       10000550
      C=PTASK(L,II)*U(J,KK,ID)*YPINT(LL)                                10000560
      WRITE(4,1361) NP(ID),NP(KA),NP(L), NP(JJ),NP(L), C                10000570
 1361 FORMAT     (4X,1HP,3I2,3X, 1HX,A2,1HP,A2, 4X, F12.4)              10000580
      IF (LL.NE.5) GO TO 500                                            10000590
      IF (KA.GT.10) GO TO 500                                           10000600
      WRITE(6,1360) NP(ID),NP(KA),NP(L), NP(JJ),NP(L), C                10000610
 1360 FORMAT(2H *,4X,1HP,3I2,3X, 1HX,A2,1HP,A2, 4X, F12.4)              10000620
  500 CONTINUE                                                          10000630
      WRITE(4,1371) NP(ID),NP(KA),NP(L), NP(ID),NP(L), ONE              10000640
      NCOL=NCOL+1                                                       10000650
 1371 FORMAT     (4X,1HP,3I2, 3X, 1HT,I2,1HP,A2, 4X, F12.4)             10000660
      IF (LL.NE.5) GO TO 510                                            10000670
      IF (KA.GT.10) GO TO 510                                           10000680
      WRITE(6,1370) NP(ID),NP(KA),NP(L), NP(ID),NP(L), ONE              10000690
 1370 FORMAT(2H *,4X,1HP,3I2, 3X, 1HT,I2,1HP,A2, 4X, F12.4)             10000700
  510 CONTINUE                                                          10000710
  520 CONTINUE                                                          10000720
      LENP=NPERYP(LL,2)-NPERYP(LL,1)+1                                  10000730
C                                                                       10000740
C  NOW GENERATE THE XJJLLMM COLUMNS                                     10000750
      DO 570 JJ=1,NVP                                                   10000760
      IS=NVEHU(JJ)                                                      10000770
      GO TO(570,525),IS                                                 10000780
C  IS=2 INDICATES VEHICLE JJ IS USED IN PERIOD L                        10000790
```

```
  525 J=NAMEN(JJ)                                                    10005800
      CALL YRCOST(J)                                                 10005810
      C=0                                                            10005820
      DO 526 IS=1,LENP                                               10005830
  526 C=C + COSTS(IS,1)                                              10005840
      IF(NPERYR(LL,2).EQ. LY) GO TO 528                              10005850
      C=C - COSTS(LENP,2)                                            10005860
      GO TO 527                                                      10005870
  528 C=C - COSTS(LENP,3)                                            10005880
  527 WRITE(4,1391)  NP(JJ),NP(L),NP(L), NP(JJ), ONE                 10005890
 1391 FORMAT     (4X,1HX,3A2, 3X, 4HSUMX,A2, 4X, F12.4)              10005900
      IF (LL.NE.5) GO TO 530                                         10005910
      WRITE(6,1390)  NP(JJ),NP(L),NP(L), NP(JJ), ONE                 10005920
 1390 FORMAT(2H *,4X,1HX,3A2, 3X, 4HSUMX,A2, 4X, F12.4)              10005930
  530 WRITE(4,1401) NP(JJ),NP(L), NP(L), NP(JJ),NP(L), ONEM          10005940
 1401 FORMAT     (4X,1HX,3A2, 3X, 1HX,A2,1HP,A2,4X, F12.4)          10005950
      IF (LL.NE.5) GO TO 531                                         10005960
      WRITE(6,1400) NP(JJ),NP(L), NP(L), NP(JJ),NP(L), ONEM          10005970
 1400 FORMAT(2H *,4X,1HX,3A2, 3X, 1HX,A2,1HP,A2,4X, F12.4)          10005980
  531 IF (LL.NE.5) GO TO 529                                         10005990
      WRITE (6,1384) NP(JJ),NP(L),NP(L),NP(L),VCOST( J,5)            10006000
 1384 FORMAT (2H *,4X,1HX,3A2,3X,2HPC,A2,6X,F12.4)                   10006010
      WRITE(6,1380) NP(JJ),NP(L),NP(L), C                            10006020
 1380 FORMAT(2H *,4X,1HX,3A2, 3X, 4HCOST,6X,F12.4)                   10006030
  529 WRITE (4,1385) NP(JJ),NP(L),NP(L),NP(L),VCOST( J,5)            10006040
 1385 FORMAT      (4X,1HX,3A2,3X,2HPC,A2,6X,F12.4)                   10006050
      WRITE (4,1381) NP(JJ),NP(L),NP(L),C                            10006060
      MCOL=MCOL+1                                                    10006070
 1381 FORMAT     (4X,1HX,3A2, 3X, 4HCOST,6X,F12.4)                   10006080
      LP1=LL + 1                                                     10006090
      IF (LP1 .GT. NPT) GO TO 570                                    10006100
      DO 545 L1=LP1,NPT                                              10006110
C                                                                    10006130
C  MAKE SURE VEHICLE JJ IS USED IN PERIOD L1.                        10006140
      IF( VLIFE(J) .LE. (NPERYR(L1,1) - NPERYR(LL,1)) ) GO TO 545    10006120
      NU=NPERYR(L1,3)                                                10006150
      DO 540 II=1,NU                                                 10006160
      L2=L1-NINHP                                                    10006170
      ID=NPTASK(L,II)                                                10006180
      NA=NTSK(ID)                                                    10006190
      DO 535 KK=1,NA                                                 10006200
      IF( U(J,KK,ID) .NE. 0.0) GO TO 5411                            10006210
  535 CONTINUE                                                       10006220
  540 CONTINUE                                                       10006230
      GO TO 545                                                      10006240
 5411 ALPHA=VCOST(J,4)                                               10006250
      C=1.0                                                          10006260
      LLL3=0                                                         10006270
      DO 5442 L3=LL,L1                                               10006280
      C=-C                                                           10006290
      L4=L3-NINHP                                                    10006300
      IF (LL.NE.5) GO TO 5443                                        10006310
      WRITE(6,1400) NP(JJ),NP(L),NP(L2), NP(JJ),NP(L4), C            10006320
 5443 WRITE(4,1401) NP(JJ),NP(L),NP(L2), NP(JJ),NP(L4), C            10006330
      LLL3=LLL3+ (NPERYR(L3,2)-NPERYR(L3,1)) + 1                     10006340
      C=ALPHA**LLL3                                                  10006350
 5442 CONTINUE                                                       10006360
      C=0                                                            10006370
```

```
      LLL1=NPERYR(L1,2)-NPERYR(LL,1) + 1                                 10006380
      DO 542 IS=1,LLL1                                                   10006390
  542 C=C + COSTS(IS,1)                                                  10006400
      IF(NPERYR(L1,2) .EQ. LY) GO TO 543                                 10006410
      C=C - COSTS(LLL1,2)                                                10006420
      GO TO 544                                                          10006430
  543 C=C - COSTS(LLL1,3)                                                10006440
  544 WRITE (4,1385) NP(JJ),NP(L),NP(L2),NP(L),VCOST( J,5)               10006450
      WRITE (4,1381) NP(JJ),NP(L),NP(L2),C                               10006460
      MCOL=MCOL+1                                                        10006470
      IF (LL.NE.5) GO TO 5441                                            10006480
      WRITE (6,1384) NP(JJ),NP(L),NP(L2),NP(L),VCOST( J,5)               10006490
      WRITE(6,1380) NP(JJ),NP(L),NP(L2), C                               10006500
 5441 WRITE(4,1381) NP(JJ),NP(L),NP(L2), NP(JJ), ONE                     10006510
      IF (LL.NE.5) GO TO 545                                             10006520
      WRITE(6,1390) NP(JJ),NP(L),NP(L2), NP(JJ), ONE                     10006530
  545 CONTINUE                                                           10006540
C                                                                        10006550
C  NOW GENERATE THE SJJLL COLUMN                                         10006560
C                                                                        10006570
      CALL MOTH(J)                                                       10006580
      WRITE(4,1411) NP(JJ),NP(L), C                                      10006590
 1411 FORMAT     (4X, 1HS,2A2,5X, 4HCOST,6X, F12.4)                      10006600
      MCOL=MCOL+1                                                        10006610
      WRITE (4,1412) NP(JJ),NP(L),NP(JJ),NP(L),ONE                       10006620
 1412 FORMAT (4X,1HS,2A2,5X,1HX,A2,1HP,A2,4X,F12.4)                      10006630
      IF (LL.NE.5) GO TO 570                                             10006640
      WRITE(6,1410) NP(JJ),NP(L), C, NP(JJ),NP(L), ONE                   10006650
 1410 FORMAT(2H *,4X, 1HS,2A2,5X, 4HCOST,6X, F12.4, 3X,1HX,A2,1HP,A2,    10006660
     * 4X,F12.4)                                                         10006670
  570 CONTINUE                                                           10006680
  600 CONTINUE                                                           10006690
C                                                                        10006700
C  NOW GENERATE THE RIGHT-HAND-SIDE ELEMENTS                             10006710
      WRITE(6,1420)                                                      10006720
 1420 FORMAT(2H *,7HRHS)                                                 10006730
      WRITE(4,1421)                                                      10006740
      MCOL=MCOL+1                                                        10006750
 1421 FORMAT     (3HRHS)                                                 10006760
C                                                                        10006770
C                                                                        10006780
C    GENERATE THE RHS FOR PROCUREMENT CONSTRAINTS                        10006790
C                                                                        10006800
      IA=NPT-NINHP                                                       10006810
      DO 610 I=1,IA                                                      10006820
      IB=I+NINHP                                                         10006830
      WRITE (4,1435) NP(I),BUDG(IB)                                      10006840
 1435 FORMAT       (4X,4HRHS1,6X,2HPC,A2,6X,F12.4)                       10006850
      WRITE (6,1434) NP(I),BUDG(IB)                                      10006860
 1434 FORMAT (2H *,4X,4HRHS1,6X,2HPC,A2,6X,F12.4)                        10006870
  610 CONTINUE                                                           10006880
C                                                                        10006890
C  GENERATE THE RHS FOR INHERITED FLEET ROWS                             10006900
  615 IF(NIV .EQ. 0) GO TO 650                                           10006910
      DO 640 II=1,NIV                                                    10006920
      JJ=IHVN(II)                                                        10006930
      J=NAMEN(JJ)                                                        10006940
      DO 630 I=1,NINHP                                                   10006950
```

```
      IF(YAVL(J) .GT. NPERYR(I,2)) GO TO 630                            10006960
      ISUM=0                                                            10006970
      IA=MAX0(YAVL(J),NPERYR(I,1)) - YAVL(J) + 1                        10006980
      IB=NPERYR(I,2) - YAVL(J) + 1                                      10006990
      DO 620 K=IA,IB                                                    10007000
  620 ISUM=ISUM + INH(J,K)                                              10007010
      IF(ISUM .EQ. 0) GO TO 630                                         10007020
      C=FLOAT(ISUM)                                                     10007030
      WRITE(6,1440) NP(JJ), NPM(I), C                                   10007040
 1440 FORMAT(2H *,4X, 4HPHS1,6X, 2HIW,A2,1HP,A2,3X, F12.4)              10007050
      WRITE(4,1441) NP(JJ), NPM(I), C                                   10007060
 1441 FORMAT     (4X, 4HPHS1,6X, 2HIW,A2,1HP,A2,3X, F12.4)              10007070
  630 CONTINUE                                                          10007080
  640 CONTINUE                                                          10007090
C                                                                       10007100
C NOW GENERATE THE RHS FOR THE TASK ROWS                                10007110
  650 IA=NINHP+1                                                        10007120
      DO 700 LL=IA,NPT                                                  10007130
      L=LL-NINHP                                                        10007140
      NU=NPERYR(LL,3)                                                   10007150
      DO 690 K=1,NU                                                     10007160
      KT=NPTASK(L,K)                                                    10007170
      WRITE(6,1450) NP(KT), NP(L), ONE                                  10007180
 1450 FORMAT(2H *,4X, 4HRHS1,6X, 1HT,A2,1HP,A2,4X,F12.4)                10007190
      WRITE(4,1451) NP(KT), NP(L), ONE                                  10007200
 1451 FORMAT     (4X, 4HRHS1,6X, 1HT,A2,1HP,A2,4X,F12.4)                10007210
  690 CONTINUE                                                          10007220
  700 CONTINUE                                                          10007230
      WRITE(6,1460)                                                     10007240
 1460 FORMAT(2H *,  6HENDATA)                                           10007250
      WRITE(4,1461)                                                     10007260
 1461 FORMAT     (  6HENDATA)                                           10007270
      END FILE 4                                                        10007280
       CALL MATFILL(NROW,MCOL,UB,NVR)                                   10007290
      WRITE (6,3000) NROW,MCOL,(UB(I),I=1,NVR)                          10007300
 3000 FORMAT (*0 IMPORTANT DATA ITEMS FOR INPUT TO BBCAVLP * /          10007310
     A * NUMBER OF ROWS (INCLUDING COST) IS *,I4 /                      10007320
     B * NUMBER OF COLUMNS (INCLUDING RHS) IS *,I7 /                    10007330
     C * UPPER BOUNDS FOR VEHICLES IN ORDER FROM X1 THRU XN ARE */      10007340
     D (1H ,10X,F12.4))                                                 10007350
C                                                                       10007360
C   PRODUCE OUTPUT LISTING FOR DOCUMENTATION OF RUN                     10007370
C                                                                       10007380
       WRITE (6,2010)                                                   10007390
       WRITE (6,2020)                                                   10007400
 2010 FORMAT (*1     VEHICLE   VARIABLE  PURCHASE     O AND M      R AND D 10007410
     *    RETENTION   YEAR FIRST  LIFE IN*)                             10007420
 2020 FORMAT (*      NAME      NAME      COST         COST         COST    10007430
     *    RATE        AVAILABLE   YEARS*)                               10007440
      IY=SY                                                             10007450
C                                                                       10007460
C   LIST VEHICLE VARIABLE NAME, AND COST DATA                           10007470
C                                                                       10007480
      DO 800 I=1,NVR                                                    10007490
      II=NAMEN(I)                                                       10007500
      WRITE (6,2030) VNAME(II),NP(I),(VCOST(II,J),J=1,4),YAVL(II),      10007510
     *VLIFE(II)                                                         10007520
 2030 FORMAT (1HO,4X,A8,7X,1HX,A2,4(F9.4,4X),2X,I4,8X,I2)               10007530
```

```
      IF (YAVL(II).LT.IY) IY=YAVL(II)                                   10007540
  830 CONTINUE                                                          10007550
C                                                                       10007560
C     DESCRIBE THE INHERITED FLEET                                      10007570
C                                                                       10007580
      IF (IY.EQ.SY) GO TO 821                                           10007590
      WRITE (6,2040)                                                    10007600
 2040 FORMAT (*-    COMPONENTS OF THE INHERITED FLEET*)                 10007610
      IF ((SY-IY).GT.20) IY=SY-20                                       10007620
      DO 810 I=IY,SY                                                    10007630
      II=I-IY+1                                                         10007640
  810 YEAR(II)=I                                                        10007650
      INHYRS=SY-IY                                                      10007660
      WRITE (6,2050) (YEAR(I),I=1,INHYRS)                               10007670
 2050 FORMAT (1H0,20X,20(I5))                                           10007680
      NA=NVR-NTV+1                                                      10007690
      DO 820 I= 1,NVR                                                   10007700
      J=NAMEN(I)                                                        10007710
      IF(YAVL(J).GE.SY) GO TO 820                                       10007720
      KK=YAVL(J)-IY                                                     10007730
      DO 815 K=1,INHYRS                                                 10007740
      IF (KK.LT.K) GO TO 814                                            10007750
      YEAR(K)=0                                                         10007760
      GO TO 815                                                         10007770
  814 K1=K-KK                                                           10007780
      YEAR(K)=INH(J,K1)                                                 10007790
  815 CONTINUE                                                          10007800
      WRITE (6,2060) NR(I),(YEAR(K),K=1,INHYRS)                         10007810
 2060 FORMAT (15H     NUMBER OF X,A2,4X,20(I5))                        10007820
  820 CONTINUE                                                          10007830
C                                                                       10007840
C     FOR EACH PERIOD , LIST ALL OF THE APPLICABLE TASK MATRICES        10007850
C                                                                       10007860
  821 IA=NTNHP+1                                                        10007870
      DO 850 I=IA,NPT                                                   10007880
      WRITE (6,2070) NPERYR(I,1),NPERYR(I,2)                            10007890
 2070 FORMAT  (35H-    TASKS REQUIRED IN PERIOD FROM ,I4,9H THROUGH ,I4)10007900
      M=NPERYR(I,2)                                                     10007910
      DO 845 J=1,M                                                      10007920
      IM=I-NTNHP                                                        10007930
      JJ=NPTASK(IM,J)                                                   10007940
      WRITE (6,2080) NR(JJ), PTASK(IM,J),  YRINT(I)                     10007950
 2080 FORMAT (1H0,6X,*TASK *,A2,*  -  PERFORMED BY *,F5.2,* FORCE ELEMEN10007960
     *T(S), WITH SCALE FACTOR EQUAL *,F5.3)                             10007970
      TT=0                                                              10007980
      IF (YRINT(I).NE. 1.0) GO TO 845                                   10007990
      WRITE (6,2090)                                                    10008000
 2090 FORMAT (1H ,6X,1H*)                                               10008010
C                                                                       10008020
C     DETERMINE WHICH VEHICLES ARE USED IN EACH TASK , JJ.....          10008030
C                                                                       10008040
C          (I=PERIOD, K=VEHICLE, II=NUMBER OF VEHICLES USED,            10008050
C          KK=NUMBER OF ALTERNATIVES)                                   10008060
C                                                                       10008070
      KK=NTSK(JJ)                                                       10008080
      DO 830 K=1,NVR                                                    10008090
      N=NAMEN(K)                                                        10008100
      DO 829 L=1,KK                                                     10008110
```

```
      IF (U(N,L,JJ).EQ.0) GO TO 829                                    10008120
      II=II+1                                                          10008130
      NL(II)=NP(K)                                                     10008140
      NN(II)=N                                                         10008150
      NAMES(II)=K                                                      10008160
      GO TO 830                                                        10008170
  829 CONTINUE                                                         10008180
  830 CONTINUE                                                         10008190
      WRITE (6,2100) (NL(K),K=1,II)                                    10008200
 2100 FORMAT (1H ,7X,11H* VARIABLE ,10(3X,1HX,A2))                     10008210
      WRITE (6,2110)                                                   10008220
 2110 FORMAT (1H ,8X,9H**********)                                     10008230
      WRITE (6,2120)                                                   10008240
 2120 FORMAT (1H ,6X,11HALTERNATIVE)                                   10008250
C                                                                      10008260
C     FILL IN TASK MATRIX                                              10008270
C                                                                      10008280
      DO 844 L=1,KK                                                    10008290
      DO 840 K=1,IT                                                    10008300
      N=NN(K)                                                          10008310
      GO TO (831,832,833,834,835,836,837,838,839),K                    10008320
  831 WRITE (6,2131) L,U(N,L,JJ)                                       10008330
 2131 FORMAT (1H ,15X,T2,2X,F5.0)                                      10008340
      GO TO 840                                                        10008350
  832 WRITE (6,2132) U(N,L,JJ)                                         10008360
 2132 FORMAT (1H+,25X,F5.0)                                            10008370
      GO TO 840                                                        10008380
  833 WRITE (6,2133) U(N,L,JJ)                                         10008390
 2133 FORMAT (1H+,31X,F5.0)                                            10008400
      GO TO 840                                                        10008410
  834 WRITE (6,2134) U(N,L,JJ)                                         10008420
 2134 FORMAT (1H+,37X,F5.0)                                            10008430
      GO TO 840                                                        10008440
  835 WRITE (6,2135) U(N,L,JJ)                                         10008450
 2135 FORMAT (1H+,43X,F5.0)                                            10008460
      GO TO 840                                                        10008470
  836 WRITE (6,2136) U(N,L,JJ)                                         10008480
 2136 FORMAT (1H+,49X,F5.0)                                            10008490
      GO TO 840                                                        10008500
  837 WRITE (6,2137) U(N,L,JJ)                                         10008510
 2137 FORMAT (1H+,55X,F5.0)                                            10008520
      GO TO 840                                                        10008530
  838 WRITE (6,2138) U(N,L,JJ)                                         10008540
 2138 FORMAT (1H+,61X,F5.0)                                            10008550
      GO TO 840                                                        10008560
  839 WRITE (6,2139) U(N,L,JJ)                                         10008570
 2139 FORMAT (1H+,67X,F5.0)                                            10008580
  840 CONTINUE                                                         10008590
  844 CONTINUE                                                         10008600
  845 CONTINUE                                                         10008610
  850 CONTINUE                                                         10008620
      STOP                                                             10008630
      END                                                              10008640
```

```
      SUBROUTINE MATFILL(N,M,UB,NVR)                                    10000650
      DIMENSION RVAL(120),RNAME(120)                                    10000660
      DIMENSION IROWTP(100)                                             10000670
      DIMENSION UB(1)                                                   10000680
      DATA IT,II / 1HT,1HI /                                            10000690
      DATA C / 7HCOLUMNS /,R / 3HRHS  /                                 10000700
      I=0                                                               10000710
      J=0                                                               10000720
      DO 400 K=1,100                                                    10000730
  400 IROWTP(K)=0                                                       10000740
      REWIND 4                                                          10000750
      WRITE(9,7000) M,N,(UB(I),I=1,NVR)                                 10000760
 7000 FORMAT(2I5/(6F12.4))                                              10000770
      READ (4,4000) DUM1,DUM2                                           10000780
      IF (EOF,4) 120,1                                                  10000790
    1 WRITE(9,4000) DUM1,DUM2                                           10000800
 4000 FORMAT (A4,10X,A8)                                                10000810
      READ (4,4100) DUM3                                                10000820
 4100 FORMAT (A4)                                                       10000830
      DO 10 I=1,N                                                       10000840
      READ (4,4200) RNAME(I)                                            10000850
 4200 FORMAT (4X,A7)                                                    10000860
      ENCODE(1,9000,ITEMP) RNAME(I)                                     10000870
      IF(ITEMP.EQ.IT.OR.ITEMP.EQ.II) IROWTP(I)=4                        10000880
 9000 FORMAT(A1)                                                        10000890
      IF (EOF,4) 120,11                                                 10000900
   10 CONTINUE                                                          10000910
      READ (4,4300)  DUM4                                               10000920
 4300 FORMAT (A7)                                                       10000930
      IF (DUM4.EQ.C)GO TO 20                                            10000940
      WRITE  (6,4400) DUM4                                              10000950
 4400 FORMAT(* INCORRECTLY READ FILE----COLUMNS READ AS *,A7)           10000960
      RETURN                                                            10000970
   20 READ (4,4500) CNAME,RTEMP,VAL                                     10000980
 4500 FORMAT (4X,A7,3X,A7,3X,F12.4)                                     10000990
      WRITE (6,5000)                                                    10001000
 5000 FORMAT (*1 REFERENCE LIST FOR COLUMN NUMBERS AND NAMES*)          10001010
      WRITE(6,6100) (IROWTP(K),K=1,N)                                   10001020
      WRITE(9,6000) (IROWTP(K),K=1,N)                                   10001030
 6000 FORMAT(I12)                                                       10001040
 6100 FORMAT(1H ,100I1)                                                 10001050
      L=1                                                               10001060
      DO 100 J=1,M                                                      10001070
      GO TO (21,22,23,24,25),L                                          10001080
   21 WRITE (6,5100) J,CNAME                                            10001090
 5100 FORMAT (1H ,4X,I5,4X,A7)                                          10001100
      GO TO 26                                                          10001110
   22 WRITE (6,5200) J,CNAME                                            10001120
 5200 FORMAT (1H+,24X,I5,4X,A7)                                         10001130
      GO TO 26                                                          10001140
   23 WRITE (6,5300) J,CNAME                                            10001150
 5300 FORMAT (1H+,44X,I5,4X,A7)                                         10001160
      GO TO 26                                                          10001170
   24 WRITE (6,5400) J,CNAME                                            10001180
 5400 FORMAT (1H+,64X,I5,4X,A7)                                         10001190
      GO TO 26                                                          10001200
   25 WRITE (6,5500) J,CNAME                                            10001210
```

```
5500 FORMAT (1H+,84X,I5,4X,A7)                                          10009220
  26 L=L+1                                                              10009230
     IF(L.GT.5)L=1                                                      10009240
     WRITE(7,5700) J,CNAME                                              10009250
5700 FORMAT(I5,4X,A7)                                                   10009260
     DO 30 I=1,N                                                        10009270
  30 RVAL(I)=0.0                                                        10009280
  40 DO 50 I=1,N                                                        10009290
     IF (RTEMP.NE.RNAME(I)) GO TO 50                                    10009300
     RVAL(I)=VAL                                                        10009310
     GO TO 60                                                           10009320
  50 CONTINUE                                                           10009330
  60 IF (J.NE.(M-1)) GO TO 80                                           10009340
     IF (I.NE.N) GO TO 80                                               10009350
     READ (4,4600) DUM5                                                 10009360
4600 FORMAT (A3)                                                        10009370
     IF (EOF,4) 120,70                                                  10009380
  70 IF (DUM5.EQ.R) GO TO 80                                            10009390
     WRITE (6,4700) CNAME                                               10009400
4700 FORMAT(* THE M-1 COLUMN WAS *,A7,* ,UNABLE TO FIND RHS MARK*)      10009410
     RETURN                                                             10009420
  80 READ (4,4500) CTEMP,RTEMP,VAL                                      10009430
     IF (EOF,4) 120,90                                                  10009440
  90 IF (CTEMP.EQ.CNAME) GO TO 40                                       10009450
     CNAME=CTEMP                                                        10009460
     WRITE (9,4800) (RVAL(K),K=1,N)                                     10009470
4800 FORMAT (F12.4)                                                     10009480
 100 CONTINUE                                                           10009490
     END FILE 9                                                         10009500
     END FILE 7                                                         10009510
     RETURN                                                             10009520
 120 WRITE (6,4900) J,I                                                 10009530
4900 FORMAT(* REACHED EOF WHILE WRITING COLUMN *,I7,* AND ROW *,I4)     10009540
     RETURN                                                             10009550
     END                                                                10009560
```

```
      SUBROUTINE VPCOST(J)                                                  10008630
C  A SUBROUTINE TO COMPUTE THE OPERATING, SALVAGE, AND TRUNCATION          10008640
C  COSTS YEAR BY YEAR.  ALSO THE YEARLY MOTHBALLING SAVING IS COMPUTED.    10008650
      COMMON /VECSTG/ VNAME(10), C,LENP, VLIFE(10), INH(10,16),             10008660
     * VCOST(10,5), NAMEN(10), COSTS(30,7)                                  10008670
      INTEGER VNAME,VLIFE                                                   10008680
C  ASSUME THE OPERATING AND MAINTANCE COST INCREASES AT R*100 PER-CENT      10008690
C  A YEAR (NOT A COMPOUND RATE INCEASE)                                     10008700
      R=0.0                                                                 10008710
C                                                                           10008720
C  LET X= THE 1ST YEAR O. AND M. COST.  THEN                                10008730
C                              X+(1+R)*X+(+2*R)*X+...+(1+9*R)*X=VCOST(J,2)10008740
      X= VCOST(J,2)/(10.0 + 45.0*R)                                         10008750
C  ASSUME NO PERIOD IS LONGER THAN 6 YEARS.                                 10008760
      I9=VLIFE(J) +10                                                       10008770
      DO 10 I=1,I9                                                          10008780
      COSTS(I,1)=(1.0 + FLOAT(I-1)*R)*X*(VCOST(J,4)**(I-1))                 10008790
   10 CONTINUE                                                              10008800
C                                                                           10008810
C  ASSUME THE SALVAGE VALUE OF A VEHICLE AFTER I YEARS OF SERVICE IS        10008820
C  (ALPHA)**I *PURCHASE COST.                                               10008830
      ALPHA=0.5                                                             10008840
      Y=VCOST(J,1)                                                          10008850
      DO 20 I=1,I9                                                          10008860
      Y= ALPHA*Y                                                            10008870
      COSTS(I,2)=Y                                                          10008880
   20 CONTINUE                                                              10008890
C                                                                           10008900
C        ASSUME TRUNCATION AFTER IYEARS OF SERVICE IS                       10008910
C              (VLIFE-I)*(PURCHASE COST)/VLIFE                              10008920
C                                                                           10008930
      Y=VCOST(J,1)/VLIFE(J)                                                 10008940
      DO 30 I=1,I9                                                          10008950
      IX=VLIFE(J)-I                                                         10008960
      IF (IX.LT.0) IX=0                                                     10008970
      COSTS(I,3)=IX*Y                                                       10008980
   30 CONTINUE                                                              10008990
      RETURN                                                                10009000
      ENTRY MOTH                                                            10009010
C  ASSSUME THE MOTHBALLING SAVING IS R1*100 PER CENT OF THE FIRST YEAR COST-X
      R1=0.90
C     C=0
C     DO 546 IL=1,LENP
C 546 C=C-0.1*R1*VCOST(J,2)*VCOST(J,4)**(IL-1)
C     C =-X * R1
      C=-VCOST(J,2)/(10.0 + 45.0*R) * R1
      RETURN                                                                10009080
      END                                                                   10009090
```

```
      SUBROUTINE YINTERP (NVR,NTR,NYR)                                  10010040
      COMMON /TSKSTG/ U(7,288,9) ,NTSK( 9)                              10010050
      COMMON / ALTSTG / ALTER(288,9),YAVL(10)                           10010060
      INTEGER ALTER                                                     10010070
      INTEGER JSUB(10),YAVL                                             10010080
      DO 20 I=1,NTR                                                     10010090
      N=NTSK(I)                                                         10010100
      DO 10 J=1,N                                                       10010110
   10 ALTER(J,I)=1                                                      10010120
   20 CONTINUE                                                          10010130
      DO 30 I=1,NVR                                                     10010140
      IF (YAVL(I).LE.NYR) GO TO 30                                      10010150
      IVR=I                                                             10010160
      GO TO 40                                                          10010170
   30 CONTINUE                                                          10010180
      RETURN                                                            10010190
   40 L=0                                                               10010200
      DO 50 J=IVR,NVR                                                   10010210
      IF (YAVL(J).LE.NYR) GO TO 50                                      10010220
      L=L+1                                                             10010230
      JSUB(L)=J                                                         10010240
   50 CONTINUE                                                          10010250
C                                                                       10010260
C  THE SET OF VEHICLES WHICH WILL NOT EXIST IN YEAR NYR                 10010270
C     HAS BEEN DEFINED ---- NOW WE WILL ORDER THE SET                   10010280
C     IN THE REVERSE OF THE ORDER IN WHICH THEY WILL                    10010290
C     BE DEVELOPED......                                                10010300
C                                                                       10010310
      DO 70 I=1,L                                                       10010320
      N=I                                                               10010330
      K=JSUB(I)                                                         10010340
      DO 60 J=N,L                                                       10010350
      M=JSUB(J)                                                         10010360
      IF (YAVL(M).LE.YAVL(K)) GO TO 60                                  10010370
      JSUB(J)=K                                                         10010380
      JSUB(I)=M                                                         10010390
      K=M                                                               10010400
   60 CONTINUE                                                          10010410
   70 CONTINUE                                                          10010420
C                                                                       10010430
C  FOR EACH TASK, WE WILL DEFINE THE SET OF ALTERNATIVES                10010440
C     WHERE THE #NON-EXISTENT# VEHICLES ARE DOING ONLY                  10010450
C     THOSE TASKS WHICH ARE THEIR PRIMARY RESPONSIBILITY,               10010460
C     THAT IS, WHERE THE REQUIREMENT FOR THEM IS A MINIMUM.....         10010470
C                                                                       10010480
      DO 150 I=1,NTR                                                    10010490
      N=NTSK(I)                                                         10010500
      DO 140 JJ=1,L                                                     10010510
      J=JSUB(JJ)                                                        10010520
      VMIN=9999.                                                        10010530
      DO 100 K=1,N                                                      10010540
      IF (ALTER(K,I).EQ.0) GO TO 100                                    10010550
      IF (U(J,K,I).LT.VMIN) VMIN=U(J,K,I)                               10010560
  100 CONTINUE                                                          10010570
      DO 130 K=1,N                                                      10010580
      IF (ALTER(K,I).EQ.0) GO TO 130                                    10010590
      IF (U(J,K,I).EQ.VMIN) GO TO 130                                   10010600
```

```
      ALTFP(K,T)=0                                                    10010610
  130 CONTINUE                                                        10010620
  140 CONTINUE                                                        10010630
  150 CONTINUE                                                        10010640
      RETURN                                                          10010650
      END                                                             10010660
```

```
      PROGRAM 98CAV2(INPUT,OUTPUT,TAPE4,TAPE1,TAPE2,                    20000010
     1 TAPE3,TAPE7,TAPE8,TAPE5=INPUT,TAPE6=OUTPUT,                      20000020
     2 TAPE9=TAPE4)                                                     20000030
C                                                                       20000040
C  LABELLED  COMMON                                                     20000050
      COMMON / CV1 / IP(12),RP(12),TMP(10)                              20000060
      COMMON / CV2 / T(100,10),BO(100),BLO(10),ULO(10),CO(10)           20000070
      COMMON / CV3 / M,N,NCF,PHIT,UZ,USP,USM,EKO,MPLUS                  20000080
      COMMON / CV4 / IX(110),X(110),IXZ(110),XZ(110),XCON(10),COST      20000090
      COMMON / CV5 / SIGMA(100,4),TSIG ,LSTMAX                          20000100
      COMMON / CV7 / NPHASE,NF1,CFX,IOPT,NOP,NOPS,NEWXZ                 20000110
      COMMON / CV8 / NXRK,XK,NOBOL,EKBL(25)                             20000120
      COMMON / CV9 / PSIGL(25),NXBL(25),XNXBL(25),BLIST(25,131)         20000130
       COMMON/TMX/TMO,EXT,TITLE(4)                                      20000140
C                                                                       20000150
       INTEGER UB,CI,BV                                                 20000160
       DIMENSION TSTO(130),LSTFRE(25)                                   20000170
       DIMENSION BLT(10),ULT(10),CT(10)                                 20000180
C                                                                       20000190
C                                                                       20000200
    7 READ(5,4448)(TITLE(I),I=1,4)                                      20000210
      IF(EOF,5)1,2                                                      20000220
    1 END FILE 8                                                        20000230
      STOP0003                                                          20000240
    2 CALL PARAMS                                                       20000250
      RP(12)=0.0                                                        20000260
      IP(9)=25                                                          20000270
      NFREF=0                                                           20000280
       CT = 4                                                           20000290
       UB = 3                                                           20000300
       LB = 2                                                           20000310
       BV = 1                                                           20000320
       MNC =(-1)* NCF                                                   20000330
       MNX = (-1)* N                                                    20000340
       EPSI = RP(1)                                                     20000350
       NORA = IP(2)                                                     20000360
      MPLUS=NORA+NCF                                                    20000370
       NOPS = 1                                                         20000380
       NCF4 = NCF * 3 + NORA                                            20000390
C                                                                       20000400
      CALL READIN                                                       20000410
       CALL BOX1                                                        20000420
C                                                                       20000430
C  SOLVE 1ST LP-PROBLEM                                                 20000440
C                                                                       20000450
   55  CONTINUE                                                         20000460
       US = USP                                                         20000470
       IF(UZ .LT. 0.0) US = USM                                         20000480
      IF (NOP.GE.IP(12)) GO TO 4444                                     20000490
      LSTMAX=MAXO(LSTMAX,NOBOL)                                         20000500
      PMIN=1.E20                                                        20000510
      DO 3000 I=1,NOBOL                                                 20000520
      IF(PSIGL(I).GE.PMIN) GO TO 3000                                   20000530
      PMIN=PSIGL(I)                                                     20000540
      NMIN=I                                                            20000550
 3000 CONTINUE                                                          20000560
      IF(PMIN.LT.US) GO TO 3020                                         20000570
```

```
      WRITE(6,3010)                                                    20000580
 3010 FORMAT(1H-,14HPROBLEM SOLVED)                                    20000590
      GO TO 4446                                                       20000600
 3020 PSIGL(NMIN)=1.E20                                                20000610
      NEREF=NEREF+1                                                    20000620
      LSTREF(NEREF)=NMIN                                               20000630
      NXBK=NXBL(NMIN)                                                  20000640
      EKO=EKBL(NMIN)                                                   20000650
      XK=XNXBL(NMIN)                                                   20000660
      DO 3030 J=1,NCF                                                  20000670
      J1=NOBA+J                                                        20000680
      J2=NCF+J1                                                        20000690
      J3=NCF+J2                                                        20000700
      BLO(J)=BLIST(NMIN,J1)                                            20000710
      ULO(J)=BLIST(NMIN,J2)                                            20000720
 3030  CO(J)=BLIST(NMIN,J3)                                            20000730
      DO 3040 J=1,NOBA                                                 20000740
 3040  BO(J)=BLIST(NMIN,J)                                             20000750
      INDIC=1                                                          20000760
       BBK = BLO(NXBK)                                                 20000770
       UBK = ULO(NXBK)                                                 20000780
C                                                                      20000790
C                                                                      20000800
       DO 10 I = 1,NCF                                                 20000810
       TMP(I) = 0.0                                                    20000820
       BLT(I) = 0.0                                                    20000830
       ULT(I) = 0.0                                                    20000840
       CT(I) = 0.0                                                     20000850
   10  CONTINUE                                                        20000860
       DO 30 I = 1,NCF4                                                20000870
C                                                                      20000880
C  REDEFINE SIGMA FOR 1ST-LP-BB FROM KO-DATA                           20000900
C                                                                      20000910
   30  TSTO(I) = 0.0                                                   20000880
      NMIN=NOBA-1                                                      20000920
      DO 552 I=1,NMIN                                                  20000930
  552  SIGMA(I,BV) = BO(I)                                             20000940
       DO 553 I = 1, NCF                                               20000950
       SIGMA(I,LB) = BLO(I)                                            20000960
       SIGMA(I,UB) = ULO(I)                                            20000970
       SIGMA(I,CI)= CO(I)                                              20000980
  553  CONTINUE                                                        20000990
       XKSTO = XK                                                      20001000
C                                        SET  X(K) = Y(K)              20001010
       XK = XK - BBK                                                   20001020
C                                        SET UPPER BOUND = Y(K)        20001030
       SIGMA(NXBK,UB)= XK                                              20001040
       TSIG =EKO                                                       20001050
      SIGMA(NOBA,BV)=-TSIG                                             20001060
      BO(NOBA)=-TSIG                                                   20001070
C                                                                      20001080
       BLT(NXBK)= SIGMA(NXBK,LB)                                       20001090
       ULT(NXBK)=XK + BLT(NXBK)                                        20001100
C                                        SLOPE OF X(NXBK) (0 TO XK)    20001110
C                                        SHIFTED RIGHT BY BLT(NXBK)    20001120
      BLO(NXBK)=BLT(NXBK)                                              20001130
      ULO(NXBK)=XK                                                     20001140
       CALL GETC (NXBK,BLT,ULT,CT)                                     20001150
```

```
      SIGMA(NXBK,CI) = CT(NXBK)                                          20001160
      CO(NXBK)=CT(NXBK)                                                  20001170
       NOP = NOP + 1                                                     20001180
C                                    SOLVE K PRIME LP PROBLEM            20001190
      DO 5555 IND=1,MPLUS                                                20001200
      X(IND)=0                                                           20001210
 5555 IX(IND)=0                                                          20001220
      CALL TABOUT (1)                                                    20001230
      NCF1=NCF                                                           20001240
      NF1=0                                                              20001250
      CALL LP (NOPA,N,NCF1)                                              20001260
      CALL TABOUT (2)                                                    20001270
       CALL TIMEC                                                        20001280
       COST1 = COST                                                      20001290
       IF(NF1 .NE. 1)GO TO 90                                            20001300
   57  CONTINUE                                                          20001310
      DO 6665 J=1,NCF                                                    20001320
      TMP(J)=0                                                           20001330
 6665 XCON(J)=0                                                          20001340
      DO 6666 IND=1,MPLUS                                                20001350
      IF (IX(IND).GT.NCF .OR. IX(IND).EQ.0) GO TO 6666                   20001360
      ICOL=IX(IND)                                                       20001370
      TMP(ICOL)=X(IND)                                                   20001380
      X(IND)=X(IND)+BLO(ICOL)                                            20001390
      XCON(ICOL)=X(IND)                                                  20001400
C                                    DEFINE X(K) FROM Y(K)               20001410
 6666 CONTINUE                                                           20001420
      IND=0                                                              20001430
      DO 6677 J=1,NCF                                                    20001440
      IF (BLO(J).EQ. 0.0) GO TO 6677                                     20001450
      IF (XCON(J).GT.0.0) GO TO 6677                                     20001460
      XCON(J)=BLO(J)                                                     20001470
      IX(MPLUS-IND)=J                                                    20001480
       X(MPLUS-IND)=BLO(J)                                               20001490
      IND=IND+1                                                          20001500
 6677 CONTINUE                                                           20001510
      RP(12)=COST-TSIG                                                   20001520
      DO 6667 J=1,NCF                                                    20001530
 6667 RP(12)=RP(12)-TMP(J)*CO(J)                                         20001540
       NOPS = NOPS + 1                                                   20001550
       MNY = (-N)                                                        20001560
       CALL TIMEC                                                        20001570
C                                    EVALUATE OBJECTIVE F(X)             20001580
      CALL GETPHI (MNC,XCON,TMP,PHIT)                                    20001590
       CALL TIMEC                                                        20001600
C                                                                        20001610
       WRITE(6,573) PHIT                                                 20001620
  573 FORMAT(1H0,11HPHI(XADJ) =,1PE18.7)                                 20001630
      IF (IP(11).EQ.1)                                                   20001640
     *WRITE (6,575) (IX(I),X(I),I=1,MPLUS)                               20001650
  575 FORMAT (1H0,5(7H   COL ,I4,2H =,F12.4))                            20001660
C                                                                        20001670
C                                                                        20001680
       IF(PHIT .GE. UZ)GO TO 70                                          20001690
C  PHIT .LT. UZ FOR 1ST-PROBLEM                                          20001700
C                                                                        20001710
       UZ = PHIT                                                         20001720
      DO 58 I=1,MPLUS                                                    20001730
```

```
      IX2(I)=IX(I)                                                      20001740
   58  X7(I)   = X(I)                                                   20001750
      NEWX7=1                                                           20001760
       USP = (UZ/(1.0 + EPSI))                                          20001770
       USM = (UZ/(1.0 - EPSI))                                          20001780
       US = USP                                                         20001790
       IF(UZ .LT. 0.0)US = USM                                          20001800
   70  CONTINUE                                                         20001810
       IF(COST1 .GE. US)GO TO 99                                        20001820
       CALL NXBRN(XCON, SIGMA, NXB)                                     20001830
  199  IF(NEREF.LE.0) GO TO 2000                                        20001840
      NOL=LSTEPF(NEREF)                                                 20001850
      NEREF=NEREF-1                                                     20001860
      GO TO 2010                                                        20001870
 2000 NOBOL=NOBOL+1                                                     20001880
      NOL=NOBOL                                                         20001890
      IF(NOBOL.LE.IP(9)) GO TO 2010                                     20001900
      WRITE(6,2020)                                                     20001910
 2020 FORMAT(1H-,*BLIST SIZE EXCEEDED*)                                 20001920
      GO TO 4446                                                        20001930
 2010 PSIGL(NOL)=COST                                                   20001940
      NXBL(NOL)=NXB                                                     20001950
      EXBL(NOL)=TSTG                                                    20001960
      XNXBL(NOL)=XCON(NXB)                                              20001970
      DO 2030 J=1,NCF                                                   20001980
      J1=NOBA+J                                                         20001990
      J2=NCF+J1                                                         20002000
      J3=NCF+J2                                                         20002010
      BLIST(NOL,J1)=SIGMA(J,LB)                                         20002020
      BLIST(NOL,J2)=SIGMA(J,UB)                                         20002030
 2030 BLIST(NOL,J3)=SIGMA(J,CT)                                         20002040
      DO 2040 J=1,NOBA                                                  20002050
 2040 BLIST(NOL,J )=SIGMA(J,BV)                                         20002060
      IF(INDIC.EQ.2) GO TO 55                                           20002070
   90  CONTINUE                                                         20002080
      INDIC=2                                                           20002090
       DO 91 I = 1,NCF                                                  20002100
       BLT(I) = 0.0                                                     20002110
       ULT(I) = 0.0                                                     20002120
       CT(I) = 0.0                                                      20002130
       TMP(I) = 0.0                                                     20002140
   91  CONTINUE                                                         20002150
C                                                                       20002160
C  REDEFINE SIGMA FOR 2ND-LP-PB FROM KB-DATA                            20002170
C                                                                       20002180
       DO  95 I=1,NMIN                                                  20002190
        SIGMA(I,BV) = BO(I)                                             20002200
        SIGMA(I,BV) = SIGMA(I,BV)- ( T(I,NXBK)*YK)                      20002210
       BO(I)=SIGMA(I,BV)                                                20002220
   95  CONTINUE                                                         20002230
       DO 96 I = 1,NCF                                                  20002240
       SIGMA(I,LB) = BLO(I)                                             20002250
       SIGMA(I,UB) = ULO(I)                                             20002260
       SIGMA(I,CT) = CO(I)                                              20002270
C                                    DEFINE LOWER BOUND OF X(K)         20002280
C                                    IF BBK = 0                         20002290
   96  CONTINUE                                                         20002300
C                                    SET UPPER BOUND OF Y(K).           20002310
```



```
      SUBROUTINE READIN                                                 20003660
```

```
C                                       THIS IS THE ONLY BOUND FOR        20002320
C                                       THIS VARIABLE SENT TO THE LP CODE 20002330
      BBK2 = BBK + XK                                                     20002340
      UBK2 = UBK-XK                                                       20002350
      SIGMA(NXBK,UB) = UBK2                                               20002360
      SIGMA(NXBK,LB) = BBK2                                               20002370
      BLT(NXBK) = BBK                                                     20002380
      CALL GETPHI(NXBK,BLT,TMP,DMY)                                       20002390
      PH1 = TMP(NXBK)                                                     20002400
      BLT(NXBK) = BBK2                                                    20002410
      CALL GETPHI(NXBK,BLT,TMP,DMY)                                       20002420
      PH2 = TMP(NXBK)                                                     20002430
      IP2 = 0                                                             20002440
      TSIG = EK0  - PH1 + PH2                                             20002450
     SIGMA(NORA,RV)=-TSIG                                                 20002460
     BO(NORA)=-TSIG                                                       20002470
      BLT(NXBK) = BBK2                                                    20002480
      ULT(NXBK) = BBK2 + UBK2                                             20002490
C                                       SET SLOPE OF X(K), IF BBK = 0     20002500
     BLO(NXBK)=BLT(NXBK)                                                  20002510
     ULO(NXBK)=UBK2                                                       20002520
      CALL GETC (NXBK,BLT,ULT,CT)                                         20002530
      SIGMA(NXBK,CI) = CT(NXBK)                                           20002540
     CO(NXBK)=CT(NXBK)                                                    20002550
      NOP = NOP + 1                                                       20002560
C                                       SOLVE K DOUBLE PRIME LP PROBLEM   20002570
     DO 7777 IND=1,MPLUS                                                  20002580
     X(IND)=0                                                             20002590
 7777 IX(IND)=0                                                           20002600
     CALL TABOUT (1)                                                      20002610
     NCF1=NCF                                                             20002620
     NF1=0                                                                20002630
     CALL LP (NORA,N,NCF1)                                                20002640
     CALL TABOUT (2)                                                      20002650
      COST2 = COST                                                        20002660
      IF(NF1 .NE. 1)GO TO 55                                              20002670
  104  CONTINUE                                                           20002680
      NOPS = NOPS + 1                                                     20002690
     DO 8887 J=1,NCF                                                      20002700
     TMP(J)=0                                                             20002710
 8887 XCON(J)=0                                                           20002720
     DO 8888 IND=1,MPLUS                                                  20002730
     IF (IX(IND).GT.NCF .OR. IX(IND).EQ.0) GO TO 8888                     20002740
     ICOL=IX(IND)                                                         20002750
     TMP(ICOL)=X(IND)                                                     20002760
     X(IND)=X(IND)+BLO(ICOL)                                              20002770
     XCON(ICOL)=X(IND)                                                    20002780
 8888 CONTINUE                                                            20002790
     IND=0                                                                20002800
     DO 8899 J=1,NCF                                                      20002810
     IF (BLO(J).EQ. 0.0) GO TO 8899                                       20002820
     IF (XCON(J).GT.0.0) GO TO 8899                                       20002830
     XCON(J)=BLO(J)                                                       20002840
     IX(MPLUS-IND)=J                                                      20002850
      X(MPLUS-IND)=BLO(J)                                                 20002860
     IND=IND+1                                                            20002870
 8899 CONTINUE                                                            20002880
     RP(12)=COST-TSIG                                                     20002890
```

```
      DO 8889 J=1,NCF                                                   20002900
 8889 PP(12)=PP(12)-TMP(J)*CO(J)                                        20002910
      CALL GETPHI (MNC,XCON,TMP,PHIT)                                   20002920
C                                                                       20002930
       WRITE(6,573) PHIT                                                20002940
      IF (IP(11).EQ.1)                                                  20002950
     *WRITE (6,575) (IX(I),X(I),I=1,MPLUS)                              20002960
C                                                                       20002970
       IF(PHIT .GE. UZ)GO TO 139                                        20002980
       UZ = PHIT                                                        20002990
      DO 107 I=1,MPLUS                                                  20003000
      IX7(I)=IX(I)                                                      20003010
  107  X7(I)    =   X(I)                                                20003020
      NEWX7=1                                                           20003030
       USP = ( UZ /(1.0 + EPST))                                        20003040
       USM = ( UZ /(1.0 - EPSI))                                        20003050
       US = USP                                                         20003060
       IF(UZ .LT. 0.0)US = USM                                          20003070
  109  CONTINUE                                                         20003080
      IF(COST2.GE.US) GO TO 55                                          20003090
       CALL NXPPN(XCON, SIGMA, NXP)                                     20003100
      GO TO 1990                                                        20003110
 4444 WRITE (6,4445)                                                    20003120
 4445 FORMAT (* HAVE SOLVED MAX. NO. OF L2 PROJS. SET BY IP(12)*)       20003130
 4446 WRITE(8,4448)(TITLE(I),I=1,4)                                     20003140
 4448 FORMAT(4A10)                                                      20003150
      WRITE(8,4447)(IX7(I),X7(I),I=1,MPLUS)                             20003160
 4447 FORMAT(I4,4X,F12.4)                                               20003170
      WRITE(8,4447)MNC,UZ                                               20003180
      NEWXZ=1                                                           20003190
      CALL TABOUT (3)                                                   20003200
      GO TO 7                                                           20003210
   26  CALL EXIT                                                        20003220
       END                                                              20003230
```

```
      SUBROUTINE BOX1                                                   20003240
C                                                                       20003250
C  LABELLED  COMMON                                                     20003260
      COMMON / CV1 / IP(12),RP(12),TMP(10)                              20003270
      COMMON / CV2 / T(100,10),BO(100),BLO(10),ULO(10),CO(10)           20003280
      COMMON / CV3 / M,N,NCF,PHIT,UZ,USP,USM,EKO,MPLUS                  20003290
      COMMON / CV4 / IX(110),X(110),IXZ(110),XZ(110),XCON(10),COST       20003300
      COMMON / CV5 / STGMA(100,4),TSIG ,LSTMAX                          20003310
      COMMON / CV7 / NPHASE,NF1,CFX,IOPT,NOP,NOPS,NEWXZ                 20003320
      COMMON / CV8 / NXBK,XK,NOBOL,EKBL(25)                             20003330
      COMMON / CV9 / PSIGL(25),NXBL(25),XNXBL(25),BLTST(25,131)         20003340
C                                                                       20003350
C                                                                       20003360
      INTEGER UB,CI,BV                                                  20003370
C                                                                       20003380
C  BOX NO. 1  (NOP = 1)                                                 20003390
C                                                                       20003400
       CI = 4                                                           20003410
      UB = 3                                                            20003420
      LB = 2                                                            20003430
      BV = 1                                                            20003440
      NORA = IP(2)                                                      20003450
      MNC =(-1)* NCF                                                    20003460
      MNX = (-1)* N                                                     20003470
      CALL GETC (MNC,BLO,ULO,CO)                                        20003480
      CALL INITA (NCF,N,NORA)                                           20003490
       CALL GETPHI(MNC,PLO,TMP,ESIG)                                    20003500
       EKO = ESIG                                                       20003510
C  SET ISIGMA FOR 1ST LP PROB.                                          20003520
      DO 10 I = 1,NCF                                                   20003530
      TMP(I) = 0.0                                                      20003540
       SIGMA(I,LB)=BLO(I)                                               20003550
      SIGMA(I,UB)=ULO(I)                                                20003560
      SIGMA(I,CI)=CO(I)                                                 20003570
   10 CONTINUE                                                          20003580
      DO 15 I = 1,NORA                                                  20003590
      SIGMA(I,BV)= BO(I)                                                20003600
   15 CONTINUE                                                          20003610
      TSIG = EKO                                                        20003620
C                                                                       20003630
      NOP = 1                                                           20003640
      DO 5555 IND=1,MPLUS                                               20003650
      XZ(IND)=0                                                         20003660
      IXZ(IND)=0                                                        20003670
      X(IND)=0                                                          20003680
 5555 IX(IND)=0                                                         20003690
      CALL TABOUT (1)                                                   20003700
      NCF1=NCF                                                          20003710
      NF1=0                                                             20003720
      CALL LP (NORA,N,NCF1)                                             20003730
      CALL TABOUT (2)                                                   20003740
       IF(NF1 .NE. 1)GO TO 7                                            20003750
   28 CONTINUE                                                          20003760
      DO 31 J=1,NCF                                                     20003770
   31 XCON(J)=0                                                         20003780
      DO 6666 IND=1,MPLUS                                               20003790
      IF (IX(IND).GT.NCF .OR. IX(IND).EQ.J) GO TO 6666                  20003800
```

```
      ICOL=IX(IND)                                                      20003810
      X(IND)=X(IND)+RLO(ICOL)                                           20003820
      XCON(ICOL)=X(IND)                                                 20003830
 6666 CONTINUE                                                          20003840
      DO 30 J=1,MPLUS                                                   20003850
      IXZ(J)=IX(J)                                                      20003860
       XZ(J) = X(J)                                                     20003870
   30  CONTINUE                                                        20003880
      NEWXZ=1                                                           20003890
      PP(12)=COST                                                       20003900
      DO 6667 J=1,NCF                                                   20003910
 6667 PP(12)=PP(12)-XCON(J)*CO(J)                                       20003920
      CALL GETPHI (MNC,XCON,TMP,UZ)                                     20003930
       EPST = PP(1)                                                     20003940
       USP= (UZ /(1.0 + EPSI))                                          20003950
       USM= (UZ /(1.0 - EPSI))                                          20003960
       EKO = TSIG                                                       20003970
C                                                                       20003980
C   10  SEP  68                                                         20003990
      CALL NXBRN (XCON,SIGMA,NXB)                                       20004000
      LSTMAX=1                                                          20004010
      NOBOL=1                                                           20004020
      BSIGL(1)=COST                                                     20004030
      XK=XCON(NXB)                                                      20004040
      XNXBL(1)=XCON(NXB)                                                20004050
      NXBL(1)=NXB                                                       20004060
      EKBL(1)=TSIG                                                      20004070
   51  CONTINUE                                                         20004080
       DO 52 I = 1,NCF                                                  20004090
       BLO(I) = SIGMA(I,LB)                                             20004100
       CO(I)  = SIGMA(I,CI)                                             20004110
       ULO(I) = SIGMA(I,UB)                                             20004120
      I1=NOBA+I                                                         20004130
      I2=NCF+I1                                                         20004140
      I3=NCF+I2                                                         20004150
      BLIST(1,I1)=BLO(I)                                                20004160
      BLIST(1,I2)=ULO(I)                                                20004170
      BLIST(1,I3)=CO(I)                                                 20004180
   52  CONTINUE                                                         20004190
       DO 53 I = 1,NOBA                                                 20004200
       BO(I)  = SIGMA(I,BV)                                             20004210
      BLIST(1,I )=BO(I)                                                 20004220
   53  CONTINUE                                                         20004230
  777  RETURN                                                           20004240
    7 CALL BBCAV2                                                       20004250
       END                                                              20004260
```

```
      SUBROUTINE GETASQ(NOES,ELM,JSQ)
C...SHELL METHOD OF HALVING
C
C  GETASQ(NOES,ELM,JSQ)  SORTS ELM(J),J=1,NOES IN AN ASCENDING SEQUENCE
C  PRESET INITIAL POSITION CODE OF ELM(J)
C  JSQ(J) PRESET TO (-1) WHEN ELM(J) IS UNDEFINED (I.E. INFINITE)
C
      DIMENSION ELM(1), JSQ(1)
      L = 1
    7 L = 2 * L
      IF( L.LE. NOES) GO TO 7
      L = L - 1
   10 L = L / 2
      DO 20 K2 = 1, NOES
      K1 = K2
   15 K3 = K1 + L
      IF( K3 .GT. NOES) GO TO 30
      IF( ELM(K1).LE. ELM(K3) ) GO TO 20
      RT = ELM(K1)
      ELM(K1 ) = ELM(K3)
      ELM(K3) = RT
      RT = JSQ(K1)
      JSQ(K1) = JSQ(K3)
      JSQ(K3) = RT
      K1 = K1 - L
      IF( K1 .GE. 1) GO TO 15
   20 CONTINUE
   30 IF( L .GT. 1) GO TO 10
      RETURN
     END
```

```
      SUBROUTINE GETC (KCX,RLT,ULT,CT)                                  20004610
      COMMON / CV1 / IP(12),RP(12),TMP(10)                              20004610
      COMMON / CV3 / M,N,NCF,PHIT,UZ,UTP,USM,EKO,MPLUS                  20004620
       DIMENSION RLT(01),ULT(01),CT(01),FX1(10),FX2(10)                 20004630
C                                                                       20004640
C  IF (KCX) 1. .GT. 0, EVALUATE KCX(TH) C(X)-SLOPE.                     20004650
C           2. .LT. 0, EVALUATE CX(1) TO CX(IFX), (IFX = -KFX).         20004660
C           3. .EQ. 0, INVALID KCX **** USE.                            20004670
C                                                                       20004680
      IF(IP(6) .EQ. 1) WRITE(6,999)                                     20004690
  999 FORMAT(1H-,124X,6HGETC  )                                         20004700
      IF(KCX .GT. N)  GO TO 770                                         20004710
      IF(KCX)200,770,100                                                20004720
  100 FX1(KCX) = 0.0                                                    20004730
      FX2(KCX) = 0.0                                                    20004740
      CALL GETPHI(KCX,RLT,FX1,DMY)                                      20004750
      CALL GETPHI(KCX,ULT,FX2,DMY)                                      20004760
      NDX1 = KCX                                                        20004770
      NDX2 = KCX                                                        20004780
      GO TO 220                                                         20004790
  200 ICX =(-1) * KCX                                                   20004800
      IF( ICX .GT. N) GO TO 770                                         20004810
      DO 210 I = 1,ICX                                                  20004820
      FX1(I) = 0.0                                                      20004830
      FX2(I) = 0.0                                                      20004840
      CT(I)  = 0.0                                                      20004850
  210 CONTINUE                                                          20004860
      CALL GETPHI(KCX,RLT,FX1,DMY)                                      20004870
      CALL GETPHI(KCX,ULT,FX2,DMY)                                      20004880
      NDX1 = 1                                                          20004890
      NDX2 = ICX                                                        20004900
  220 DO 225 J = NDX1,NDX2                                              20004910
      DIF = ULT(J) - RLT(J)                                             20004920
      IF(DIF    .EQ. 0.0) GO TO 225                                     20004930
      CT(J) = (FX2(J) - FX1(J)) / DIF                                   20004940
  225 CONTINUE                                                          20004950
      GO TO 777                                                         20004960
  770 WRITE(6,771)KCX                                                   20004970
  771 FORMAT(1H1,13HINVALID KCX =,I3,1CH  IN GETC   )                   20004980
      CALL EXIT                                                         20004990
C                                                                       20005000
  777 CONTINUE                                                          20005010
  888 RETURN                                                            20005020
C                                                                       20005030
      END                                                               20005040
```

```
      SUBROUTINE GETPHI(KFX,XPHI,PHI,SUMPHI)                          20005050
      DIMENSION XPHI(61),PHI(61)                                      20005060
      COMMON / CV1 / IP(12),RP(12),TMP(10)                            20005070
      COMMON / CV2 / T(100,10),BO(100),BLO(10),ULO(10),CO(10)         20005080
      COMMON / CV3 / M,N,NCF,PHIT,UZ,USP,USM,EKO,MPLUS                20005090
C                                                                     20005100
C  IF (KFX)  1. .GT.  0, EVALUATE  KFX(TH) F(X).                      20005110
C            2. .LT.  0, EVALUATE  FX(1) TO FX(IFX), (IFX = -KFX).    20005120
C            3. .EQ.  0, INVALID KFX **** UEP.                        20005130
C                                                                     20005140
      IF(IP(6) .EQ. 1) WRITE(6,999)                                   20005150
  999 FORMAT(1H-,124X,6HGETPHI)                                       20005160
C                                                                     20005170
      IF(KFX)100,300,500                                              20005180
  100 SUMPHI=PP(12)                                                   20005190
      I = 1                                                           20005200
  160 IF(I+KFX) 150,150,400                                           20005210
  150 IF(I.GT.4)GO TO 140                                             20005220
      GO TO (101,102,103,104) I                                       20005230
  101 IF(XPHI(I).LT..001) GO TO 140                                   20005240
      PHI(I)= 0.30 + 0.006*XPHI(I)**0.95                              20005250
      GO TO 200                                                       20005260
  102 PHI(I)= 0.0038*XPHI(I)**0.96                                    20005270
      GO TO 200                                                       20005280
  103 PHI(I)= 0.006*XPHI(I)**0.90                                     20005290
      GO TO 200                                                       20005300
  104 PHI(I)= 0.015*XPHI(I)**0.909                                    20005310
      GO TO 200                                                       20005320
  140 PHI(I) = 0.0                                                    20005330
  200 SUMPHI = SUMPHI + PHI(I)                                        20005340
      IF(KFX.GT.0) RETURN                                             20005350
      I = I+1                                                         20005360
      GO TO 160                                                       20005370
  500 SUMPHI = 0.0                                                    20005380
      I = KFX                                                         20005390
      GO TO 150                                                       20005400
  300 WRITE(6,301)                                                    20005410
  301 FORMAT(1H1,25HKFX = 0 IN GETPHI          )                      20005420
      CALL EXIT                                                       20005430
  400 RETURN                                                          20005440
      END                                                             20005450
```

```
      SUBROUTINE INITA(NCF,N,M)                                          20005460
                                                                         20005470
C                                                                        20005480
C         THIS SUBROUTINE COPIES THE A MATRIX FROM TAPE TO DISC          20005490
C         AND STORES THE BO AND CO ARRAYS IN CORE. TAPE9 IS ASSUMED      20005500
C         TO BE THE TAPE AND TAPE3 IS THE DISC FILE.                     20005510
C                                                                        20005520
      COMMON / CV2 / T(100,10),BO(100),BLO(10),ULO(10),CO(10)            20005530
      COMMON /POWTYP/ IPOWTP(101)                                        20005540
      DIMENSION AJ(100)                                                  20005570
      REWIND 3                                                           20005580
C     REWIND 9                                                           20005590
      READ (9,100) DUM1,DUM2                                             20005600
  100 FORMAT (A4,10X,A8)                                                 20005610
      READ(9,400)(IPOWTP(J),J=1,M)                                       20005620
  400 FORMAT(I12)                                                        20005630
      DO 10 I=1,N                                                        20005640
      READ (9,200) (AJ(J),J=1,M)                                         20005650
  200 FORMAT (F12.4)                                                     20005660
      IF(EOF,9) 1000,20                                                  20005670
   20 IF (I.NE.N) GO TO 40                                               20005680
      DO 30 J=1,M                                                        20005690
   30 BO(J)=AJ(J)                                                        20005700
   40 IF (I.GT.NCF) GO TO 60                                             20005710
      AJ(M)=CO(I)                                                        20005720
      DO 55 J=1,M                                                        20005730
   55 T(J,I)=AJ(J)                                                       20005740
   60 WRITE (3)     (AJ(J),J=1,M)                                        20005750
C      WRITE(7,1) (AJ(J),J=1,M)                                          20005760
1      FORMAT(5E15.5)                                                    20005770
C      WRITE(6,2) (AJ(J),J=1,M)                                          20005780
2      FORMAT(1X,5E15.6)                                                 20005790
   10 CONTINUE                                                           20005800
      IPOWTP(M)=3                                                        20005810
      END FILE 3                                                         20005820
      RETURN                                                             20005830
 1000 WRITE (6,300) I                                                    20005840
  300 FORMAT (* PREMATURE EOF ON A MATRIX TAPE AT COLUMN *,I5)           20005850
      STOP3002                                                           20005960
      END
```

```
      SUBROUTINE NXBRN(XT,SIGMAI,NXB)                                   20005870
      COMMON / CV1 / IP(12),RP(12),TMP(10)                              20005880
      COMMON / CV3 / M,N,NCF,PHIT,UZ,USP,USM,EKO,MPLUS                  20005890
      DIMENSION XT(001),BLT(10),CT(10),  YT(10),SIGMAT(100,4)           20005900
      DIMENSION  FX1(10),FX2(10),DIF(10),NDX(10)                        20005910
   10 CONTINUE                                                          20005920
      IF(IP(6) .EQ. 1) WRITE(6,999)                                     20005930
  999 FORMAT(1H-,124X,6HNXBRN )                                         20005940
      NXB =  0                                                          20005950
C  NXBRN GIVES BEST BRNCH-CANDIDATE FOR  XT(I)                          20005960
      DO 5  J = 1,NCF                                                   20005970
      FX2(J)= 0.0                                                       20005980
      FX1(J)= 0.0                                                       20005990
      DIF(J)= 0.0                                                       20006000
      NDX(J)= 0                                                         20006010
      BLT(J)=  SIGMAT(J,2)                                              20006020
      CT(J) =  SIGMAT(J,4)                                              20006030
    5 CONTINUE                                                          20006040
      DO 20 J = 1,NCF                                                   20006050
      YT(J) = XT(J) - BLT(J)                                            20006060
   20 CONTINUE                                                          20006070
      NFX =(-1) * NCF                                                   20006080
      CALL GETPHI(NFX,  XT,FX2,DMY)                                     20006090
      CALL GETPHI(NFX,BLT,FX1,DMY)                                      20006100
   40 CONTINUE                                                          20006110
     IF (RP(4).NE.0)                                                    20006120
     *WRITE (6,55)                                                      20006130
   55 FORMAT(1H0,10X,*DIFFERENCE    =*,10X,*PHI(X)   -  PHI(LOWER BOUND)20006140
     * -  (*,8X,4HC(X),4X,1H*,12X,1HX,6X,1H))                          20006150
      DO 30 J = 1,NCF                                                   20006160
      DIF(J) = FX2(J) - FX1(J) - CT(J)*YT(J)                            20006170
     IF (RP(4).NE.0)                                                    20006180
     * PRINT 50,J,DIF(J),FX2(J),FX1(J),CT(J),YT(J)                     20006190
   50 FORMAT(1H0,I5,6F20.6)                                             20006200
      NDX(J) = J                                                        20006210
   30 CONTINUE                                                          20006220
      CALL GETASQ(NCF,DIF,NDX)                                          20006230
      NXB = NDX(NCF)                                                    20006240
      RETURN                                                            20006250
 1000 CONTINUE                                                          20006260
      END                                                               20006270
```

```
      SUBROUTINE PARAMS                                                 20006280
C                                                                       20006290
C  LABELLED COMMON                                                      20006300
      COMMON / CV1 / IP(12),PP(12),TMP(10)                              20006310
      COMMON / CV2 / T(100,10),DD(100),BLO(10),ULO(10),CO(10)           20006320
      COMMON / CV3 / M,N,NCE,PHIT,UZ,USP,USM,EKO,MPLUS                  20006330
      COMMON / CV4 / TX(110),X(110),TX2(110),X2(110),XCON(10),COST       20006340
      COMMON / CV5 / STGMA(100,4),TSIG,IFIL                             20006350
      COMMON / CV7 / NPHASE,NF1,CFX,IOPT,NOP,NOPS,NEWXZ                 20006360
      COMMON / CV8 / NXPK,XK,NOBOL,EKBL(25)                             20006370
      COMMON / CV9 / PSTGL(25),NXBL(25),XNXBL(25),BLIST(25,131)         20006380
C                                                                       20006390
      READ(5,10)(IP(I),I=1,12)                                          20006400
   10 FORMAT(12I6)                                                      20006410
      REWIND 9                                                          20006420
      READ(9,11) IP(1), IP(2)                                           20006430
11    FORMAT(2I6)                                                       20006440
      IF( EOF, 5) 77777, 15                                             20006450
   15 CONTINUE                                                          20006460
C                                                                       20006470
C  IP1=N, IP2=NORA, IP3=NCE, IP4=MMAX, IP5=NMAX, IP6=LPIN, IP7=LPOUT    20006480
C  IP8=ICTU, IP9=IBMAX, IP10=JBMAX, IP11=ICK, IP12=MXNOP                20006490
C                                                                       20006500
C  N - TOTAL NO. OF VARIABLES                                           20006510
C  NORA - NO. OF ROWS IN A-MATRIX                                       20006520
C  NCE - NO. OF VARIABLES W/CONCAVE-F(X)                                20006530
C  MMAX - MAX. NO. OF CONSTRAINTS FOR JPLP                              20006540
C  NMAX - MAX. NO. OF VARIABLES FOR JPLP                                20006550
C  LPIN - IF (1) WRITE LP INPUT FOR EACH PROBLEM                        20006560
C  LPOUT - IF (1) WRITE LP OUTPUT FOR EACH PROBLEM                      20006570
C  ICTU - IF (1) CONSTRAIN COST-F(X) .LT. U0                            20006580
C  IBMAX - MAX NO. OF ROWS IN BLIST                                     20006590
C  JBMAX - MAX NO. OF COLUMNS IN BLIST                                  20006600
C  ICK - IF (1) SET PRINT = .TRUE. IN JPLP                              20006610
C  MXNOP - MAX. NO. OF LP PROBS. SOLVED BEFORE CALLING EXIT             20006620
C                                                                       20006630
      READ(5,20)(PP(I),I=1, 6)                                          20006640
   20 FORMAT( 6F12.0)                                                   20006650
C                                                                       20006660
C  PP1=EPST, PP2=TMMAX, PP3=THETA, PP4-TRACE                            20006670
C  EPSI - ADJUSTMENT FACTOR FOR U0                                      20006680
C  TMMAX - MAX.  RR-EXCT TIME IN SECONDS                                20006690
C  THETA - X(I) ZERO RNDOFF                                             20006700
C  TRACE - IF(1) TRACE SOLUTION, USING LPIN, LPOUT, AND ICK CODES       20006710
C          IF(0) SKIP ALL INTERMEDIATE PRINT OUT                        20006720
C                                                                       20006730
      TMMAX = PP(2)                                                     20006740
      CALL SET(TMMAX)                                                   20006750
C                                                                       20006760
      CALL PRESET                                                       20006770
C                                                                       20006780
      WRITE(6,30)(IP(I),I=1,12)                                         20006790
   30 FORMAT(1H1,20HINTEGER PARAMETERS =,12I6)                          20006800
      WRITE(6,40)(PP(I),I=1,6)                                          20006810
   40 FORMAT(1H-,17HREAL PARAMETERS =,6F18.8)                           20006820
      N = IP(1)                                                         20006830
      NORA = IP(2)                                                      20006840
```

```
      NCF = IP(3)                                                    20006850
      M=NCF + NORA                                                   20006860
C                                                                    20006870
      IBMAX = IP(9)                                                  20006880
C                                                                    20006890
   55 READ(9,20)(       ULO(J), J = 1,NCF)                         20006900
      DO 60 J=1,NCF                                                  20006910
      IF(ULO(J).LT.0) ULO(J) = - ULO(J)                              20006920
60    CONTINUE                                                       20006930
C     READ(5,20) (BLO(J),J=1,NCF)
      DO 61 J=1,NCF
C                                                                    20006950
61    BLO(J) = 0.0
      WRITE(6,90)                                                    20006960
   90 FORMAT(1H-,25H X(J) LOWER-UPPER BOUNDS )                       20006970
      DO 100 J = 1,NCF                                               20006980
      WRITE(6,95)J,BLO(J),ULO(J)                                     20006990
   95 FORMAT(1H0,2X,I3,3X,2E12.4)                                    20007000
  100 CONTINUE                                                       20007010
      NOBOL = 0                                                      20007020
  777 RETURN                                                         20007030
77777 CONTINUE                                                       20007040
      STOP 00001                                                     20007050
      END                                                            20007060
```

```
      SUBROUTINE PRESET                                                 20007070
C                                                                       20007080
C LABELLED COMMON                                                       20007090
      COMMON / CV1 / IP(12),PP(12),TMP(1 )                              20007100
      COMMON / CV2 / T(110,10),B0(110),BLO(10),ULO(10),CO(10)           20007110
      COMMON / CV3 / M,N,NCE,PHIT,UZ,USP,USM,EKO,MPLUS                  20007120
      COMMON / CV4 / IY(110),Y(110),IYP(110),YP(110),YCON(10),COST       20007130
      COMMON / CV5 / SIGMA(110,4),TSTG                                  20007140
      COMMON / CV7 / NPHASE,NF1,QEX,IOPT,NOP,NOPS,NEWXZ                 20007150
      COMMON / CV8 / NXBK,XK,NOBOL,EKBL(25)                             20007160
      COMMON / CV9 / PSTGL(25),NXBL(25),XNXBL(25),BLIST(25,131)         20007170
C                                                                       20007180
      IF(IP(6) .EQ. 1) WRITE(6,999)                                     20007190
  999 FORMAT(1H-,124X,6HPRESET)                                         20007200
      N=IP(1)                                                           20007210
      NOBA = IP(2)                                                      20007220
      NCE=IP(3)                                                         20007230
      IBMAX = IP(9)                                                     20007240
      JBMAX = IP(10)                                                    20007250
C                                                                       20007260
C                                                                       20007270
      DO 13 J=1,NCE                                                     20007280
      BO(J) = 0.0                                                       20007290
      BLO(J) = 0.0                                                      20007300
      ULO(J) = 0.0                                                      20007310
   13 CONTINUE                                                          20007320
C                                                                       20007330
      DO 15 I = 1,NOBA                                                  20007340
      DO 14 K=1,4                                                       20007350
   14 SIGMA(I,K)=0.0                                                    20007360
      BO(I) = 0.0                                                       20007370
   15 CONTINUE                                                          20007380
C                                                                       20007390
      NEWXZ=0                                                           20007400
      PHIT=0                                                            20007410
      UZ = 1.E+36                                                       20007420
      USP = 1.E+36                                                      20007430
      USM = 1.E+36                                                      20007440
      COST=0.0                                                          20007450
      TSTG=0.0                                                          20007460
      NF1=0                                                             20007470
      QEX=0.0                                                           20007480
      IOPT=0                                                            20007490
      NOP=0                                                             20007500
      NXBK=0                                                            20007510
      XK =0.0                                                           20007520
      NOBOL=0                                                           20007530
C                                                                       20007540
      DO 20 I =1,IBMAX                                                  20007550
      EKBL(I) = 0.0                                                     20007560
      PSTGL(I)= 0.0                                                     20007570
      NXBL(I)= 0                                                        20007580
      XNXBL(I)=0.0                                                      20007590
      DO 20 J=1,JBMAX                                                   20007600
      BLIST(I,J) = 0.0                                                  20007610
   20 CONTINUE                                                          20007620
C                                                                       20007630
```

```
      RETURN                                                    20007640
      END                                                       20007650
```

```
      SUBROUTINE READIN                                                 20007660
      COMMON / CV1 / IP(12),PP(12),TMP(1 )                              20007670
      DATA ENDER / 5HEND      /                                         20007680
      REWIND 7                                                          20008210
      NC=PP(3)                                                          20007690
      IF(NC.EQ.0) GO TO 20                                              20007700
      DO 15 I=1,NC                                                      20007710
      READ (5,100) (TMP(J),J=1,8)                                       20007720
      WRITE(7,100) (TMP(J),J=1,8)                                       20007730
  100 FORMAT (8B10)                                                     20007740
   15 CONTINUE                                                          20007750
   20 WRITE(7,100) ENDER                                                20007760
      RETURN                                                            20007770
      END                                                               20007780
```


```
      SUBROUTINE ESCAPE(D)                                              20012210
```

```
      SUBROUTINE SET(TMMAX)                                          20007790
      COMMON/TMX/TMO,EXT                                             20007800
C                                                                    20007810
C  SECOND GIVES JOB CPU EXECUTION TIME IN 1/1000 OF A SECOND         20007820
C                                                                    20007830
      CALL SECOND(TMO)                                               20007840
      EXT = TMMAX + TMO                                              20007850
      RETURN                                                         20007860
      END                                                            20007870
```

```
      SUBROUTINE TAPOUT(IPT)                                            20007880
C  LABELLED COMMON                                                      20007890
      COMMON / CV1 / IP(12),PP(12),TMP(10)                              20007900
      COMMON / CV2 / T(100,10),BO(100),BLO(10),ULO(10),CO(10)           20007910
      COMMON / CV3 / M,N,NCE,PHIT,UZ,UCP,USM,EKO,MPLUS                  20007920
      COMMON / CV4 / IX(11 ),X(110),IX7(110),X7(110),XCON(10),COST      20007930
      COMMON / CV5 / SIGMA(100,4),TSIG                                  20007940
      COMMON / CV7 / NPHASE,NE1,CEX,IOPT,NOP,NOPS,NEWX7                 20007950
      COMMON / CV8 / NXBK,YK,NOBOL,EKBL(25)                             20007960
      COMMON / CV9 / PSIGL(25),NXBL(25),YNXBL(25),BLIST(25,131)         20007970
C                                                                       20007980
      IF(NOP .GT. 1) GO TO 90                                           20007990
      GO TO 100                                                         20008000
   90 CONTINUE                                                          20008010
      IF(PP(4) .EQ. 0.0) GO TO 777                                      20008020
  100 CONTINUE                                                          20008030
      WRITE(6,101)                                                      20008040
  101 FORMAT(1H1,30HTAPOUT - GENERAL - INFORMATION)                     20008050
      IF (IPT.NE.3) CALL TIMEC                                          20008060
      WRITE(6,105)UZ,USP                                                20008070
  105 FORMAT(1H0,6HUZERO=,1PE18.7,6X,6HUSP =,1PE18.7)                   20008080
      IF (NEWX7.EQ.1)                                                   20008090
     *WRITE (6,570) (IX7(I),X7(I),I=1,MPLUS)                            20008100
  570 FORMAT (7H0X7ERO // (7X,5(7H   COL ,I4,2H =,F12.4)))              20008110
      IF (IPT.EQ.3) GO TO 777                                           20008120
      NEWX7=0                                                           20008130
      WRITE(6,109)                                                      20008140
  109 FORMAT(1H0,10HSTGMA(I,J),13X,5HPHS-P,12X,6HLW-BND,12X,6HUP-BND,   20008150
     111X,7HC-SLOPE)                                                    20008160
C                                                                       20008170
C                                                                       20008180
      DO 115 I=1,NCE                                                    20008190
      WRITE(6,113) I, (STGMA(I,J),J=1,4)                                20008200
  113 FORMAT(1H ,5X,I2,2X,4E18.6)                                       20008210
  115 CONTINUE                                                          20008220
C                                                                       20008230
      WRITE(6,117)TSIG                                                  20008240
  117 FORMAT(1H0,6HE(K) =,E18.6)                                        20008250
C                                                                       20008260
      IF(IPT.NE. 1)GO TO 145                                            20008270
C                                                                       20008280
      IF(NOBOL.LE.0) GO TO 145                                          20008290
      IT = NOBOL                                                        20008300
      DO 131 I=1,IT                                                     20008310
      WRITE(6,121)I,PSIGL(I),NXBL(I),YNXBL(I),EKBL(I)                   20008320
  121 FORMAT(14-,6HNODE =,I4,6X,6HCOST =,F20.6,6X,8HNX-BRN =,I4,6X,     20008330
     1 7HY-BRN =,F20.6,6X,6HE(K) =,F20.6)                               20008340
  131  CONTINUE                                                         20008350
  145 CONTINUE                                                          20008360
  777 RETURN                                                            20008370
      END                                                               20008380
```

```
      SUBROUTINE TIMEC                                                  20008390
      COMMON / CV3 / M,N,NCF,PHIT,UZ,USP,USM,EKO,MPLUS                  20008400
      COMMON / CV4 / IX(110),X(110),IXZ(110),XZ(110),XCON(10),COST       20008410
      COMMON / CV7 / NPHASE,NF1,CFX,IOPT,NOP,NOPS,NEWXZ                 20008420
       COMMON /TSW/ NSWW                                                20008430
       COMMON/TMX/TMO,EXT,TITLE(4)                                      20008440
C                                                                       20008451
C  SECOND GIVES JOB CPU EXECUTION TIME IN 1/10 0 OF A SECOND            20008460
C                                                                       20008470
       CALL SECOND(SECS)                                                20008480
       XX= SECS - TMO                                                   20008490
      WRITE(6,666) XX                                                   20008500
  666 FORMAT(12H0EXCT-TIME =,F9.3,8H SECONDS)                           20008510
       IF(SECS .LT. EXT) GO TO 100                                      20008520
       WRITE(6,667)                                                     20008530
  667  FORMAT(37H TIME IS UP...CYCLING TO NEXT PROBLEM)                 20008540
      MNC=(-1)*NCF                                                      20008550
 4446 WRITE(8,4448)(TITLE(I),I=1,4)                                     20008560
 4448 FORMAT(4A10)                                                      20008570
      WRITE(8,4447)(IX7(I),XZ(I),I=1,MPLUS)                             20008580
 4447 FORMAT(I4,4X,F12.4)                                               20008590
      WRITE(8,4447)MNC,U7                                               20008600
      NEWX7=1                                                           20008610
      CALL TABOUT (3)                                                   20008620
      CALL BBCAV2                                                       20008630
  100  RETURN                                                           20008640
       END                                                              20008650
```

```
      SUBROUTINE LP(MROWS,NCOLS,NCHGS)                                          20008660
      COMMON / CV1 / IP(12),PP(12),IMP(10)                                      20008670
      COMMON / CV2 / T(110,10),RO(100),BLO(1 ),UBS(1 ),CO(10)                   20008680
      COMMON / CV4 / IX(110),X(110),TX7(110),X7(110),XCON(10),COST              20008690
      COMMON / CV7 / NPHASE,NF1,CFX,IOPT,NOP,NOPS,NEWX7                         20008700
C--------SET PHS TO INPUTM+1                                                    20008710
      COMMON /PHS/ PHS(100)                                                     20008720
C--------SET AJ(AS MUCH AS POSSIBLE) OVER INPUTM+1**2 FOR CORE COLUMNS          20008730
      COMMON /CORE/ JAREJ(101),JA(101),JAK(101),AJ(11000)                       20008740
      COMMON /A/ ALPHA(101) /B/ BETA(1 1) /C/ GAMMA(101) /D/ DELTA(101)         20008750
      COMMON /DJS/ DJ(1 )                                                       20008760
C--------SET IROWTP(INPUTM+1)  NAME(INPUTM+INPUTM+1)                           20008770
      COMMON /ROWTYP/ IROWTP(101) /NAMES/ NAME(600)                             20008780
      COMMON /I/ M,L,MPL,MG,NT,ICOST,IC,IPHASE,JPHS,IPI                         20008790
      COMMON /LIMS/ MAXTRY,NTRY,JNCORE,NCRMAX,NSCAN                             20008800
      COMMON /STATE/ JROS,IROW,JCOL,JOUT,ITRN,NREJ,NPIF,NDJS                    20008810
      COMMON /FILES/ TA1,TA2,IMAP                                               20008820
      COMMON /INPUT/INPUT,INPUTM,INPUTN                                         20008830
      COMMON /BOUNDS/ BOUNDS(100),IBDS(100),NBDS                                20008840
      COMMON /PARAMS/ TMAX,ITNINV,INVF,K1,K2,K3,K4,K5                           20008850
      COMMON/IXX/IXX(100) /XX/ XX(100)                                          20008860
C-----THE B ORIGIN IS MOVED DOWN THE AJ SPACE --IGNORE SIZE                     20008870
      REAL B(100)                                                               20008880
      EQUIVALENCE (AJ,B)                                                        20008890
C                                                                               20008900
      CALL MSSG(40HLP/LONG/5-SUB CYCLIC                    )                    20008910
C-----FILE DEFINITIONS                                                          20008920
      TA1=1                                                                     20008930
      TA2=2                                                                     20008940
      INPUT=3                                                                   20008950
      IMAP=7                                                                    20008960
      REWIND INPUT                                                              20008970
      CALL FTNBIN(1,1,TA1)                                                      20008980
      CALL FTNBIN(1,1,TA2)                                                      20008990
C-----SET LENGTH OF AJ SPACE IN NWAJ                                            20009000
      NWAJ=11000                                                                20009010
C                                                                               20009020
C                                                                               20009030
C                                                                               20009040
C                                                                               20009050
C                                                                               20009060
C                                                                               20009070
C                                                                               20009080
C                                                                               20009090
      ICOST=INPUTM=MROWS                                                        20009100
      JPHS=INPUTN=NCOLS                                                         20009110
      NBDS=NCHGS                                                                20009120
      DO 10 I=1,NBDS                                                            20009130
      IBDS(I)=I                                                                 20009140
   10 BOUNDS(I)=UBS(I)                                                          20009150
C-----MAXOUT AFTER TMAX, QUIT AFTER K5 CYCLES                                   20009160
      TMAX=200.                                                                 20009170
      K5=200                                                                    20009180
C-----XCHECK BETWEEN CYCLES N300 TO NNNAT INCREMENTS K2                         20009190
       K2 = 1                                                                   20009200
      K4=100                                                                    20009210
      K4=0                                                                      20009220
```

```
      K4=1                                                              20009230
C-----PRINT CONTROL K3                                                  20009240
       K3 = 0                                                           20009250
      K3=5*7*11*13                                                      20009260
      IF(IP(8).NE.1) K3=K3/5                                            20009270
      IF(IP(7).EQ.0) K3=13*7                                            20009280
      IF(IP(4).EQ.0.0) K3=1                                             20009290
C                                                                       20009300
C                                                                       20009310
C                                                                       20009320
C                                                                       20009330
C                                                                       20009340
C                                                                       20009350
C                                                                       20009360
C                                                                       20009370
C                                                                       20009380
C                                                                       20009390
C                                                                       20009400
C                                                                       20009410
C-----PROGRAM VERBS                                                     20009420
  100  CALL SETUP                                                       20009430
       WRITE(6,999) IPOWTP                                              20009440
  999  FORMAT(* DUMP IPOWTP*/(1X,50I1))                                 20009450
C-----M IS NOW ACTUAL NON-GUB ROWS, L IS NO. OF GUB ROWS NWAJ IS AJ SPAC20009460
      ML=M+L                                                            20009470
C-----OPTIMIZE CORE COLUMN STORAGE                                      20009480
      IOPG=NWAJ-M*M                                                     20009490
      NCPMAX=MING( 99,IOPG/M)- 3                                        20009500
  200  CALL MAPIN(P(IOPG))                                              20009510
  250  FORMAT(///* LP PROBLEM DATA FOR THIS RUN *                      20009520
     +         /* NON-GUB ROWS * I6                                     20009530
     +         /*     GUB-ROWS * I6                                     20009540
     +         /                                                        20009550
     +         /* LOGICALS     * I6                                     20009560
     +         /* TOTAL COLUMNS* I6                                    20009570
     +         /* MAX IN CORE  * I6                                    20009580
     +         /* INVERT FREQU.* I6 * CYCLES*                          20009590
     +         /* MAX RUN TIME * F6 * SECONDS*                         20009600
     +         /* MAX CYCLES   * I6 * ITERATIONS*                      20009610
     +   ////)                                                          20009620
       WRITE(6,250) M,L,MC,NT,NCPMAX,INVF,TMAX,K5                       20009630
       IF (IOPG.GE.2*M) GOTO 300                                        20009640
       CALL ERROR(40HLP--INSUFFICIENT  SPACE STATED IN NWAJ      )      20009650
       CALL ESCAPE(P(IOPG))                                             20009660
  300  CALL INVERT(P(IOPG))                                             20009670
  400  CALL PRIMAL(P(IOPG))                                             20009680
       ITNINV=0                                                         20009690
       CALL INVERT(P(IOPG))                                             20009700
       IPI=IOPG+IPI-1                                                   20009710
       DO 500 J=1,NT                                                    20009720
       CALL IN(J,AJ,0)                                                  20009730
  500  OJ(J)=DOT(M,P(IPI),AJ)                                           20009740
       IPI=IPI-IOPG+1                                                   20009750
       WRITE(6,501) (J,OJ(J),NAME(J),J=1,NT)                            20009760
  501  FORMAT(*OBJ VALUES FOR FINAL SOLUTION COLUMNS*/(I10,E12.4,T10))  20009770
C-----END PHASE 2, OR UNBOUNDED OR NO FEASIBLE SOLUTION                 20009780
  900  CONTINUE                                                         20009790
       CALL MAPOUT(P(IOPG))                                             20009800
```

```
      NVAR=INPUTM+NCHGS                                              20009810
      DO 900 I=1,NVAR                                                20009820
      IX(I)=IXX(I)                                                   20009830
  900 X(I)=XX(I)                                                     20009840
      COST=-BETA(ICOST)                                              20009850
 7776 RETURN                                                         20009860
      END                                                            20009870
```

```
      FUNCTION BOUND(J)                                                 20009880
      COMMON /BOUNDS/ BOUNDS(100),IBDS(100),NBDS                        20009890
      COMMON /I/ M,L,MPL,MC,NT,ICOST,IC,IPHASE,JRHS,IPI                 20009900
      COMMON /NAMES/ NAME(100)                                          20009910
C-----PICKS UP BOUND FROM PACKED LIST,EITHER  FINITE OR  10**35         20009920
      BOUND=1.E70                                                       20009930
      IF(J.GT.NT) RETURN                                                20009940
      IB=NAME(J)/100000                                                 20009950
       IF(IB.LE.0.OR.IB.GT.NBDS) RETURN                                 20009960
      BOUND = BOUNDS(IB)                                                20009970
      RETURN                                                            20009980
      END                                                               20009990
```

```
      SUBROUTINE COLUMN(JCOL,B)                                          20010000
C-----SUB VERSION  APRIL 20-71                                           20010010
      COMMON  /MOVES/ THETA,BNDJ,DMAX,PRMLER,DUALER                      20010020
      COMMON /STATE/ JPOS,IROW,JKOL,JOUT,ITRN,NREJ,NPIF,NDJS             20010030
      COMMON /TOLS/ DJTOL,ZERO,PIVTOL,CTOL,PERTOL,DERTOL                 20010040
      COMMON /I/ M,L,MPL,MC,NT,ICOST,IC,IPHASE,JRHS,IPT                  20010050
      COMMON /LIMS/ MAXTRY,NTRY,JNCORE,NCRMAX,NSCAN                      20010060
      COMMON /A/ ALPHA(101) /B/ BETA(1 1) /C/ GAMMA(101) /D/ DELTA(101)  20010070
      COMMON /CORE/ JAREJ(101),JA(101),JAK(101),AJ(1000)                 20010080
      COMMON /NAMES/ NAME(100)                                           20010090
      COMMON /DJS/ DJ(100)                                               20010100
      LOGICAL  BASIC,ATBND,NULL,KEY                                      20010110
      REAL B(1)                                                          20010120
      KEY(I)=MOD(NAME(I),10).EQ.4                                        20010130
      NPKT(J)=MOD(NAME(J),100000)/10                                     20010140
C                                                                        20010150
C-----CHECKS COLS IN CORE, IF NONE GETS SOME, IF SOME FINDS BEST         20010160
      NTRY = 1+NTRY                                                      20010170
      MAXTRY=NCRMAX                                                      20010180
      IF( NTRY.GT. MAXTRY)  GOTO 1                                       20010190
      IF( JNCORE.NE.0)      GOTO 5                                       20010200
C-----CHECK FOR MORE COLUMNS ON DISC                                     20010210
 1    CALL DISC(B)                                                       20010220
      NTRY = 0                                                           20010230
      NDJST=NDJS                                                         20010240
      IF( JNCORE.EQ.0)      GOTO 100                                     20010250
C                                                                        20010260
C-----RE-PRICE  VECTORS IN CORE                                          20010270
 5    JORG = 1                                                           20010280
C-----NO PRICING IF REJECTS OR JUST PRICED DISC                          20010290
      IF(NREJ.NE.0  .OR.  NTRY.EQ.0) GOTO 50                             20010300
C-----PRICE OUT COLUMN                                                   20010310
      DO 40  J= 1,JNCORE                                                 20010320
      DJ(J)=DOT(M,B(IPT),AJ(JORG))                                       20010330
 40   JORG = JORG+M                                                      20010340
C                                                                        20010350
C-----NOW FIND BEST COLUMN IN CORE, NON-BASIC OR BOUNDED                 20010360
 50   DMAX=0                                                             20010370
      NDJS=0                                                             20010380
      JPKT0=0                                                            20010390
      PIKEY=0.                                                           20010400
      DO  60  J=1,JNCORE                                                 20010410
      IF(JAREJ(J).EQ.1) GOTO 60                                          20010420
      JPOS = JA(J)                                                       20010430
      JTYPE=MOD(NAME(JPOS),10)                                           20010440
      IF(JTYPE.EQ.2) GOTO 60                                             20010450
      IF(JTYPE.EQ.4) GOTO 60                                             20010460
      IF(JTYPE.EQ.0) GOTO 60                                             20010470
      JPKT=NPKT(JPOS)                                                    20010480
      IF(JPKT.EQ.0) GOTO 55                                              20010490
      IF(JPKT.EQ.JPKT0) GOTO 55                                          20010500
      JKEY=KEYEND(JPKT)                                                  20010510
C-----NEW PACKET STARTED, FIND KEY AND KEY PRICE                         20010520
      IF(JKEY.EQ.0) GOTO 60                                              20010530
      PIKEY=DJ(JKEY)                                                     20010540
      JPKT0=JPKT                                                         20010550
 55   D=DJ(J)                                                            20010560
```

```
      IF(JTYPE.EQ.3) D=-DJ(J)                                          20010570
      IF(JPKT.NE.0) D=D-PIKEY                                          20010580
      IF(D.LT.-ZERO)  NDJS=1+NDJS                                      20010590
      IF(D.GE. DMAX)  GOTO 60                                          20010600
      DMAX =D                                                          20010610
      JCOL = J                                                         20010620
 60   CONTINUE                                                         20010630
      NCORE=JNCORE                                                     20010640
C-----RESTORE COUNT OF NDJS FROM CHECK IF JUST DONE                    20010650
      IF(NTRY.EQ.0 .AND. NT.GT.NCRMAX) NDJS=NDJST                      20010660
      IF( DMAX.LT.-DJTOL)  GOTO 70                                     20010670
C-----CURRENT COLS NO-GOOD,  QUIT IF THESE ARE BEST                    20010680
      IF( NTRY.EQ.0)       GOTO 100                                    20010690
      GOTO 1                                                           20010700
C                                                                      20010710
C-----RETURN WITH COLUMN INDEX                                         20010720
  70  RETURN                                                           20010730
C                                                                      20010740
C-----NO GOOD COLS,  OPTIMUM                                           20010750
 100  JCOL=0                                                           20010760
C-----SAVE OLD COLUMNS                                                 20010770
      JNCORE=NCORE                                                     20010780
      RETURN                                                           20010790
C                                                                      20010800
      END                                                              20010810
```

```
      SUBROUTINE DISC(B)                                                20010820
C     REVISED  10/71                                                    20010830
C-----CHECKS DISC FOR COLUMNS, ACCEPTING 1/NBCH, IF NOT ALL IN CORE.    20010840
C     RETURNS  JNCORE COLUMNS AND PRICES,  OR JNCORE=0                  20010850
C-----PACKETS CAN IN BE INTER-MIXED WITH SOME LOSS OF EFFICIENCY        20010860
C     DUE TO MULTIPLE KEY SEARCHES                                      20010870
      COMMON /I/ M,L,MPL,MC,NT,ICOST,IC,IPHASE,JPHS,IPI                 20010880
      COMMON /STATE/ JPOS,IROW,JCOL,JOUT,ITRN,NREJ,NPIF,NDJS            20010890
      COMMON /TOLS/ DJTOL,ZERO,PIVTOL,CTOL,PERTOL,DERTOL                20010900
      COMMON /PARAMS/ TMAX,ITNINV,INVF,K1,K2,K3,K4,ITNCHK               20010910
      COMMON /LIMS/ MAXTRY,NTRY,JNCORE,NCPMAX,NSCAN                     20010920
      COMMON /CORE/ JAREJ(101),JA(101),JAK(101),AJ(1000)                20010930
      COMMON /BASIS/ IBASIS(101),KEYS(101)                              20010940
      COMMON /DJS/ DJ(100)                                              20010950
      COMMON /NAMES/ NAME(100)                                          20010960
      INTEGER PKT,PKTO                                                  20010970
      REAL B(1)                                                         20010980
      LOGICAL BASIC,ATBND ,NULL,CHEK                                    20010990
      NPKT(J)=MOD(NAME(J),100000)/10                                    20011000
      NULL(I)=MOD(NAME(I),10).EQ.0                                      20011010
C                                                                       20011020
C-----CHECK FOR AN INVERT (  ITRN.GE.ITNINV)                            20011030
      CALL INVERT(B)                                                    20011040
C                                                                       20011050
C-----ALL IN CORE,  NCPMAX SET IN LP                                    20011060
      IF( NT.LT.NCPMAX) GOTO 200                                        20011070
C-----ACCEPT 1 COL/NBCH COLS,  BEST AT IORG, NEW AT JORG, (ICOL,JCOL)   20011080
      NBCH=NT/NCPMAX/4+1                                                20011090
      NDJS=PKTO=JNCORE=0                                                20011100
      JORG=0                                                            20011110
      JCOL=1                                                            20011120
      IORG=M                                                            20011130
      ICOL=2                                                            20011140
      NCORE=2                                                           20011150
      CALL  INPOS(JNT)                                                  20011160
      NBCHS = (NT+NBCH-1)/NBCH                                          20011170
C                                                                       20011180
      DO 1000  JBCH  =1, NBCHS                                          20011190
      DJOLD = 1.E35                                                     20011200
      DO 100   JEBCH= 1,NBCH                                            20011210
C-----BATCH CYCLE,  NEXT COLUMN  JNT                                    20011220
      JNT= 1+MOD(JNT,NT)                                                20011230
      JTYPE =  MOD(NAME(JNT),10)                                        20011240
C-----SKIP NULL, BASIC  OR KEY COLUMNS                                  20011250
      IF(JTYPE.EQ.2)  GOTO 100                                          20011260
      IF(JTYPE.EQ.4)  GOTO 100                                          20011270
      IF(JTYPE.EQ.0)  GOTO 100                                          20011280
C                                                                       20011290
C-----IF IN A SUB PACKET, GET KEY                                       20011300
      PKT= NPKT(JNT)                                                    20011310
      IF( PKT.EQ.0    )  GOTO   20                                      20011320
      IF( PKT.EQ.PKTO)  GOTO   20                                       20011330
C-----USE AN UNUSED KEY SLOT                                            20011340
      JKEY=KEYEND(1)                                                    20011350
      IF(JKEY.NE.J) GOTO 15                                             20011360
 10   NCORE=1+NCORE                                                     20011370
      JKEY=NCORE                                                        20011380
```

```
 15   KORG= M*JKEY-M                                                    20011390
      CALL INPCKD(KEYS(PKT)/100,AJ(KORG+1),JKEY)                        20011400
      DJ(JKEY)= DOTS(M,B(IPI),AJ(KORG+1) )                              20011410
      PKTO=PKT                                                          20011420
C                                                                       20011430
C-----NOW GET COLUMN  AND DJ.                                           20011440
 20   CONTINUE                                                          20011450
      CALL IN(JNT, AJ(JORG+1), JCOL)                                    20011460
      DJ(JCOL)= DOTS(M,B(IPI),AJ(JORG+1) )                              20011470
C                                                                       20011480
C-----CORRECT FOR PACKET AND BOUND EFFECTS                              20011490
      DJNEW = DJ(JCOL)                                                  20011500
      IF(PKT.NE.0)  DJNEW = DJNEW - DJ(JKEY)                            20011510
      IF(JTYPE.EQ.3)DJNEW =-DJNEW                                       20011520
      IF( DJNEW.LT.-ZERO)   NDJS=1+NDJS                                 20011530
C                                                                       20011540
C-----SELECTION STAGE INTERCHANGE BEST FOR NEW                          20011550
      IF(DJNEW.GE.DJOLD)  GOTO 100                                      20011560
      DJOLD=DJNEW                                                       20011570
      I=ICOL                                                            20011580
        ICOL=JCOL                                                       20011590
             JCOL=I                                                     20011600
      I=IORG                                                            20011610
        IORG=JORG                                                       20011620
             JORG=I                                                     20011630
 100  CONTINUE                                                          20011640
C                                                                       20011650
      IF( DJOLD.GT.-DJTOL) GOTO  999                                    20011660
C                                                                       20011670
C-----PRESERVE THE BEST                                                 20011680
      JNCORE=1+JNCORE                                                   20011690
       NCORE=1+NCORE                                                    20011700
      ICOL   = NCORE                                                    20011710
      IORG   = M*ICOL-M                                                 20011720
 999  IF(  NCORE.GE. NCRMAX) GOTO 110                                   20011730
 1000 CONTINUE                                                          20011740
 110  CONTINUE                                                          20011750
      IF(JNCORE.NE.0) JNCORE=NCORE-1                                    20011760
      GOTO 500                                                          20011770
C                                                                       20011780
C-----ALL IN CORE CASE,  READ AND PRICE .                               20011790
 200  IF( JNCORE.EQ.0 ) GOTO250                                         20011800
      JNCORE=0                                                          20011810
      GOTO 500                                                          20011820
C                                                                       20011830
 250  CONTINUE                                                          20011840
      JORG=0                                                            20011850
      DO 300 JNT=1,NT                                                   20011860
      CALL IN(JNT,AJ( JORG+1),JNCORE+1)                                 20011870
      IF( NULL(JNT) )GOTO 300                                           20011880
      JNCORE=1+JNCORE                                                   20011890
      DJ(JNCORE) = DOTS(M,B(IPI), AJ(JORG+1))                           20011900
      JORG = M+JORG                                                     20011910
 300  CONTINUE                                                          20011920
      GOTO 500                                                          20011930
C                                                                       20011940
C-----DIAGNOSTICS   IF KT*23                                            20011950
 500  CONTINUE                                                          20011960
```

```
      IF( MOD(K3,23).NE.0 )  RETURN                                     20011970
      WRITE(6,501)     (JA(J), DJ(J), J=1,JNCOSE )                      20011980
  501 FORMAT(* DISC-PROVIDED*/(8( I5, F10.2 )) )                        20011990
      RETURN                                                            20012000
      END                                                               20012010
```

```
      FUNCTION DOT(M,X,Y)                                          20012020
C-----INNER PRODUCT OF X AND Y                                     20012030
      DOUBLE PRECISION  SUM                                        20012040
      REAL  X(1),Y(1)                                              20012050
      SUM=0.0                                                      20012060
      DO  100  I=1,M                                               20012070
      IF(Y(I).EQ.0.0) GOTO 100                                     20012080
      SUM=SUM+X(I)*Y(I)                                            20012090
  100 CONTINUE                                                     20012100
      DOT = SUM                                                    20012110
      RETURN                                                       20012120
C                                                                  20012130
C-----SINGLE PRECISION VERSION FOR SPEED                           20012140
      ENTRY DOTS                                                   20012150
      DOT=0.0                                                      20012160
      DO 200 I=1,M                                                 20012170
  200 DOT=DOT+X(I)*Y(I)                                            20012180
      RETURN                                                       20012190
      END                                                          20012200
```

```
      SUBROUTINE ESCAPE(R)                                                  20012210
C------GUB VERSION APRIL/71                                                20012220
      COMMON /PARAMS/ TMAX,ITNINV,INVF,K1,K2,K3,K4,K5                       20012230
      COMMON /LIMS/ MAXTRY,MTRY,JNCORE,NCRMAX,NSCAN                         20012240
      COMMON /T/ M,L,MPL,MC,NT,ICOST,IC,IPHASE,JPHS,IPI                     20012250
      COMMON /BASIS/ IBASIS(101),KEYS(101)                                  20012260
      COMMON /NAMES/ NAME(100)                                              20012270
      COMMON /A/ ALPHA(101) /B/ BETA(101) /C/ GAMMA(101) /D/ DELTA(101)     20012280
      COMMON /CORE/ JAREJ(101),JA(1J1),JAK(101),AJ(1000)                    20012290
      COMMON /DJS/ DJ(100)                                                  20012300
      DATA AALPHA/5HALPHA/,ABETA/4HBETA/,AGAMMA/5HGAMMA/,APT/2HPT/          20012310
      DATA  AJAREJ/5HJAREJ/,AJA/2HJA/,ANAME/4HNAME/,ABASIS/5HBASIS/         20012320
      DATA ADELTA/5HDELTA/,ADJ/2HDJ/, AKEY/3HKEY/                           20012330
      COMMON /PHS/ PHS(100)                                                 20012340
      NPRT(J)=MOD(NAME(J),100000)/1)                                        20012350
      CALL MESSG(47HESCAPED AFTER DUMP OF LP SYSTEM              )          20012360
      WRITE(6,3)  ANAME                                                     20012370
      WRITE(6,2) (NAME(J),J=1,NT)                                           20012380
      WRITE(6,3)  ABASIS                                                    20012390
      WRITE(6,2) (IBASIS(J),J=1,M)                                          20012400
      WRITE(6,3)AKEY                                                        20012410
      WRITE(6,2)(KEYS(I),I=1,L)                                             20012420
      WRITE(6,3)  AJA                                                       20012430
      WRITE(6,2) (JA(J),J=1,JNCORE)                                         20012440
      WRITE(6,3)  AJAREJ                                                    20012450
      WRITE(6,2) (JAREJ(J),J=1,JNCORE)                                      20012460
      WRITE(6,3)  AALPHA                                                    20012470
      WRITE(6,1) (ALPHA(J),J=1,MPL)                                         20012480
      WRITE(6,3)  ABETA                                                     20012490
      WRITE(6,1) (BETA (J),J=1,MPL)                                         20012500
      WRITE(6,3)  AGAMMA                                                    20012510
      WRITE(6,1) (GAMMA(J),J=1,M)                                           20012520
      WRITE(6,3) ADELTA                                                     20012530
      WRITE(6,1)(DELTA(J),J=1,M)                                            20012540
      WRITE(6,3)  ADJ                                                       20012550
      WRITE(6,1) (DJ    (J),J=1,JNCORE)                                     20012560
 1    FORMAT(1H ,10E12.5)                                                   20012570
 2    FORMAT(1H ,10I12)                                                     20012580
 3    FORMAT(1H0,A10)                                                       20012590
      CALL MAPOUT(R)                                                        20012600
C-----CAUSE A DUMP                                                         20012610
      I=0                                                                   20012620
      WRITE(I) I                                                            20012630
      RETURN                                                                20012640
      END                                                                   20012650
```

```
      SUBROUTINE EXITS                                                  20012660
      COMMON / CV7 / NPHASE,NF1,CFX,IOPT,NOP,NOPS,NEWXZ                 20012670
C-----PRIMAL CALLS THESE ENTRY POINTS AT THE END OF EACH PHASE           20012680
C-------------------------------------------------------------------------20012690
      ENTRY OPT1                                                        20012700
      NPHASE=1                                                          20012710
      RETURN                                                            20012720
C-------------------------------------------------------------------------20012730
      ENTRY OPT2                                                        20012740
      NPHASE=2                                                          20012750
       NF1 = 1                                                          20012760
      CALL STATUS(40HPPIMAL--END OF PHASE 2--OPTIMAL          )         20012770
      RETURN                                                            20012780
C-------------------------------------------------------------------------20012790
      ENTRY UNBND                                                       20012800
      NPHASE=4                                                          20012810
      CALL STATUS(40HPRIMAL--UNBOUNDED SOLUTION               )         20012820
      RETURN                                                            20012830
C-------------------------------------------------------------------------20012840
      ENTRY NOFEAS                                                      20012850
      NPHASE = 5                                                        20012860
      CALL STATUS(40HPRIMAL--NO FEASIBLE SOLUTION             )         20012870
      RETURN                                                            20012880
C-------------------------------------------------------------------------20012890
      END                                                               20012900
```

```
      SUBROUTINE FEASCH(B)                                                  20012910
C------SUB VERSION APRIL/71                                                20012920
C-----GIVEN CURRENT INVERSE B, RHS, KEY AND BOUNDS IN GAMMA                 20012930
C-----COMPUTES CURRENT SOLUTION BETA, NO. OF INFEASIBLES NPIF.              20012940
C-----IF BETA INFEAS, ADDS ARTIFICIALS AND REVERTS TO PHASE-1               20012950
      COMMON /PARAMS/ TMAX,ITNINV,INVF,K1,K2,K3,K4,K5                       20012960
      COMMON /STATE/ JROS,IROW,JCOL,JOUT,ITRN,NREJ,NPIF,NDJS                20012970
      COMMON /BASIS/ IBASIS(101),KEYS(101)                                  20012980
      COMMON /A/ ALPHA(101) /B/ BETA(101) /C/ GAMMA(101) /D/ DELTA(101)     20012990
      COMMON /I/ M,L,MPL,MC,NT,ICOST,IC,IPHASE,JRHS,IPI                     20013000
      COMMON /CORE/ JAREJ(101),JA(101),JAK(101),AJ(1000)                    20013010
      COMMON /TOLS/ DJTOL,ZERO,PIVTOL,CTOL,RERTOL,DERTOL                    20013020
      COMMON /BOUNDS/ BOUNDS(100),IBDS(100),NBDS                            20013030
      COMMON /NAMES/ NAME(100)                                              20013040
      COMMON /RHS/ RHS(100)                                                 20013050
      LOGICAL KEY                                                           20013060
      REAL B(1)                                                             20013070
      NPKT(I)=MOD(NAME(I),100000)                                           20013080
      ITP(J)=MOD(IBASIS(J),100)                                             20013090
      KEY=.FALSE.                                                           20013100
      DO 10 I=1,M                                                           20013110
 10   DELTA(I)=0.0                                                          20013120
      DELTA(M)=1.0                                                          20013130
C-----COMPUTE EFFECTIVE RHS IN GAMMA USING  KEY + BOUNDS ALREADY  THERE     20013140
      DO 20 I=1,M                                                           20013150
 20   GAMMA(I)=+GAMMA(I)+RHS(I)                                             20013160
C-----CYCLE ELEMENTS OF SOLUTION                                            20013170
      NPIF=0                                                                20013180
      SUMIF=0.                                                              20013190
      BNDJ=1.E70                                                            20013200
      IORG=1                                                                20013210
      MM1=M-1                                                               20013220
      DO 100 I=1,MM1                                                        20013230
      SUM = DOT(M, B(IORG), GAMMA )                                         20013240
      BETA(I)=SUM                                                           20013250
      IORG= M+IORG                                                          20013260
      JOUT= IBASIS(I)/100                                                   20013270
      IF(NBDS.EQ.0) GOTO 50                                                 20013280
C-----CHECK XJOUT LESS THAN BOUND                                           20013290
      BNDJ = BOUND(JOUT)                                                    20013300
      IF( SUM.LE.BNDJ+ZERO) GOTO 50                                         20013310
C-----BOUND VIOLATED, REMOVE BOUND AND TREAT AS INFEAS XJOUT                20013320
      IF(MOD(K3,13).EQ.0) WRITE(6,101) I,JOUT,SUM,BNDJ                      20013330
      CALL SETBND (JOUT)                                                    20013340
      BETA(I)=BETA(I)-BNDJ                                                  20013350
      GOTO 60                                                               20013360
C-----CHECK XJOUT POSITIVE FOR NON-FREE ROWS                                20013370
 50   IF( ITP   (I).EQ.3 )  GOTO 100                                       20013380
      IF( BETA(I).GE.-ZERO) GOTO 100                                        20013390
C-----INFEASIBLE,  ADD ARTIFICIAL TO KILL ERROR AND PIVOT IN                20013400
      IF(MOD(K3,13).EQ.0) WRITE(6,101) I,JOUT,SUM,BNDJ                      20013410
 55   CONTINUE                                                              20013420
      CALL SETBND(-JOUT)                                                    20013430
      BETA(I)= -BETA(I)                                                     20013440
 60   NPIF=1+NPIF                                                           20013450
      JPKT=0                                                                20013460
      IF(JOUT.LE.NT) JPKT=NPKT(JOUT)                                        20013470
```

```
      IF(JPKT.NE.0) KEYS(JPKT)=KEYS(JPKT)-1                              20013480
      SUMIF=SUMIF+BETA(I)                                                20013490
      IBASIS(I)=100*(100+JOUT+NT)+MOD(IBASIS(I),100)                     20013500
      DELTA(I)= -1.                                                      20013510
      IF(JOUT.GT.NT) DELTA(M)=2.                                         20013520
      CALL PIVOT(I,B,DELTA)                                              20013530
      DELTA(I)=  0.                                                      20013540
      DELTA(M)=1.                                                        20013550
      IF(KEY) GOTO 150                                                   20013560
  100 CONTINUE                                                           20013570
  101 FORMAT(* INFEAS--ROW*I5*  COL*I5*  VALUE*E12.4*  BOUND*E12.4)      20013580
C-----CONSTRUCT COMPLETE SOLUTION FOR KEYS  IN BETA(M+1)....             20013590
      IF(L.EQ.0) GOTO 151                                                20013600
      BNDJ=1.E70                                                         20013610
      KEY=.TRUE.                                                         20013620
      DO 150 K=1,L                                                       20013630
C-----CHECK PACKET HAS BASIC COLS                                        20013640
      SUM= 0.0                                                           20013650
      NR =  MOD (KEYS(K),100)                                            20013660
      IF(NR .EQ.0 )  GO TO  115                                          20013670
C-----SUM BASIC COL VALUES IN PACKET K                                   20013680
      DO 110 I=1,M                                                       20013690
      JPOS = IBASIS(I)/100                                               20013700
      IF(NPKT(JPOS).EQ.K) SUM=SUM+BETA(I)                                20013710
  110 CONTINUE                                                           20013720
  115 BETA(M+K) =  RHS(M+K)-SUM                                          20013730
      IF(BETA(M+K).GE.-ZERO) GOTO 150                                    20013740
C-----INFEASIBLE GUB, MUST BE ESSENTIAL, CHANGE TO BASIC ROW I           20013750
      JOUT=KEYS(K)/100                                                   20013760
      IF(MOD(K3,13).EQ.0) WRITE(6,111) K,JOUT,BETA(M+K),BNDJ             20013770
  111 FORMAT(* INFEAS--GUB*I5*  COL*I5*  VALUE*E12.4*  BOUND*E12.4)      20013780
      CALL KEYCH(JOUT,I,B)                                               20013790
      GOTO 55                                                            20013800
  150 CONTINUE                                                           20013810
  151 CONTINUE                                                           20013820
C-----TOTAL INFEASIBILITY                                                20013830
      BETA(M)=0.                                                         20013840
      DO 160 I=1,MM1                                                     20013850
      IF(IBASIS(I)/100.LE.NT) GOTO 160                                   20013860
      BETA(M)=BETA(M)-BETA(I)                                            20013870
  160 CONTINUE                                                           20013880
C-----INDICATE PHASE 1                                                   20013890
      IF(ABS(BETA(M)).LT.CTOL) GOTO 200                                  20013900
      IPHASE = 1                                                         20013910
      IF(MOD(K3,13).EQ.0) WRITE(6,199) SUMIF,BETA(M)                     20013920
  199 FORMAT(* TOTAL INFEASIBILITY*E12.4* PHASE1 COST*E12.4)             20013930
C-----ADJUST COST ROW           IC AND  ORIGIN IPI                       20013940
  200 IC = ICOST                                                         20013950
      IF(IPHASE.EQ.1)  IC = M                                            20013960
      IPI=1+M*IC-M                                                       20013970
C-----PHASE 1 COST IS EQUALITY ZERO IN PHASE 2                           20013980
      IBASIS(M)=100*(IBASIS(M)/100)                                      20013990
      IF(IPHASE.EQ.1) IBASIS(M)=IBASIS(M)+3                              20014000
      RETURN                                                             20014010
      END                                                                20014020
```

```
      SUBROUTINE INVERT(R)                                              20014030
C------SUB VERSION APRIL/71                                            20014040
      COMMON /BOUNDS/ BOUNDS(100),IBDS(100),NBDS                        20014050
      COMMON /STATE/ JPOS,IROW,JCOL,JOUT,ITRN,NREJ,NBTF,NDJS            20014060
      COMMON /TOLS/ OJTOL,ZERO,PIVTOL,CTOL,PERTOL,DEPTOL                20014070
      COMMON /PARAMS/ IMAX,ITNINV,INVF,K1,K2,K3,K4,ITNCHK               20014080
      COMMON /BASIS/ IBASIS(101),KEYS(101)                              20014090
      COMMON /A/ ALPHA(101) /B/ BETA(1 1) /C/ GAMMA(101) /D/ DELTA(101) 20014100
      COMMON /LIMS/ MAXTRY,NTRY,JNCORE,NCRMAX,ISCAN                     20014110
      COMMON /I/ M,L,MPL,MC,NT,ICOST,IC,IPHASE,JPHS,IPI                 20014120
      COMMON /CORE/ JAREJ(101),JA(101),JAK(101),AJ(1000)                20014130
      COMMON /NAMES/ NAME(100)                                          20014140
      COMMON /PHS/ PHS(100)                                             20014150
      REAL R(1)                                                         20014160
      INTEGER PKT,PKTO                                                  20014170
      LOGICAL BASIC,ATBND                                               20014180
      ITP(J)=MOD(IBASIS(J),100)                                         20014190
      NPKT(J)=MOD(NAME(J),100000)/10                                    20014200
C-----INVERTS CURRENT BASIS VECTORS AND ADJUSTS FOR BOUNDS              20014210
      IF(ITRN.LT.IT NINV) RETURN                                        20014220
      CALL MESSG(4CHITNVERT                                )            20014230
C-----ITERATION OF NEXT INVERT                                          20014240
      ITNINV=ITRN+INVF                                                  20014250
C                                                                       20014260
      IF(L.EQ.0) GOTO 15                                                20014270
C-----COUNT MISSING KEYS TO NKM AND CLEAR BASIC COUNT                   20014280
      NKM=0                                                             20014290
  0   DO 5 I=1,L                                                        20014300
      K=KEYS(I)/100                                                     20014310
      IF(K.EQ.0) NKM=NKM+1                                              20014320
      KEYS(I)=100*K                                                     20014330
  5   CONTINUE                                                          20014340
      IF(NKM.EQ.0) GOTO 15                                              20014350
C-----FIRST SCAN BASIC COLS FOR KEY CANDIDATES                          20014360
      JTAG=2                                                            20014370
  6   CONTINUE                                                          20014380
      DO 10 J=MC,NT                                                     20014390
      K=NPKT(J)                                                         20014400
      IF(K.EQ.0) GOTO 10                                                20014410
      JTYPE=MOD(NAME(J),10)                                             20014420
      IF(JTYPE.NE.JTAG) GOTO 10                                         20014430
      IF(KEYS(K)/100.NE.0) GOTO 10                                      20014440
C-----SET COLUMN J KEY IN PACKET K AND REDUCE COUNT NKM                 20014450
      KEYS(K)=100*J                                                     20014460
      CALL SETKEY(J)                                                    20014470
      NKM=NKM-1                                                         20014480
  10  CONTINUE                                                          20014490
      IF(NKM.EQ.0) GOTO 15                                              20014500
      IF(JTAG.NE.2) GOTO 11                                             20014510
C-----NOW EXAMINE FREE COLUMNS                                          20014520
      JTAG=1                                                            20014530
      GOTO 6                                                            20014540
  11  CONTINUE                                                          20014550
      CALL ERROR(4CHITNVERT--SEVERAL KEYS UNMARKED-DATA ERR,      )     20014560
      CALL ESCAPE(8)                                                    20014570
C                                                                       20014580
C-----NULL BASIS EXCEPT FOR FREE ROWS SAVING TYPES                      20014590
```

```
 15   CONTINUE                                                          20014600
      IORG=0                                                            20014610
      DO 20 I=1,M                                                       20014620
      GAMMA(I)=0.0                                                      20014630
      ITYPE=MOD(IBASIS(I),100)                                          20014640
      IF(ITYPE.NE.3) IBASIS(I)=ITYPE                                    20014650
C-----SET UP UNIT BASIS AND ZERO RHS                                    20014660
      DO 19 J=1,M                                                       20014670
 19   B(IORG+J)=0.                                                      20014680
      B(IORG+I)=1.0                                                     20014690
 20   IORG=IORG+M                                                       20014700
C-----RESTORE PHASE1 LOGICAL                                            20014710
      IBASIS(M)=100*MC+ITYPE                                            20014720
C                                                                       20014730
C-----CYCLE COLUMN NAMES, KEY COLUMNS TO KORG, OTHERS TO JORG           20014740
      JORG=M*JNCORE                                                     20014750
      KORG=JORG+M                                                       20014760
C-----PKT IS CURRENT GUB PACKET, PKTO IS PACKET OF LAST KEY             20014770
      PKTO=0                                                            20014780
      DO 200 JNT=1,NT                                                   20014790
      JTYPE= MOD( NAME(JNT),10)                                         20014800
      IF(JTYPE.LE.1) GOTO 200                                           20014810
C-----GET THIS BASIC/BOUNDED/KEY COL TO CORE                            20014820
      JPOS=JNT                                                          20014830
 30   CALL IN(JPOS,AJ(JORG+1),JNCORE+1)                                 20014840
      PKT=NPKT(JNT)                                                     20014850
      IF(JTYPE.GE.3) GOTO 150                                           20014860
C-----BASIC COLUMN, IS KEY NEEDED                                       20014870
      IF(PKT.EQ.0) GOTO 120                                             20014880
      IF(PKT.EQ.PKTO) GOTO 100                                          20014890
C-----GET KEY AND RECORD                                                20014900
      CALL INPCKD(KEYS(PKT)/100,AJ(KORG+1),JNCORE+2)                    20014910
      PKTO=PKT                                                          20014920
C-----REMOVE KEY COMPONENT FROM COL                                     20014930
 100  DO 110 I=1,M                                                      20014940
 110  AJ(JORG+I)=AJ(JORG+I)-AJ(KORG+I)                                  20014950
C-----TRANSFORM TO CURRENT BASIS                                        20014960
 120  IORG=1                                                            20014970
      DO 130 I=1,M                                                      20014980
      ALPHA(I)=DOT(M,B(IORG),AJ(JORG+1))                                20014990
 130  IORG=IORG+M                                                       20015000
C-----FIND BEST ROW TO PIVOT                                            20015010
      IROW=0                                                            20015020
      CALL PIVOT(IROW,B,ALPHA)                                          20015030
      IF( IROW.EQ.0) GOTO 200                                           20015040
C-----INCREASE COUNT OF BASIC COLS IN PACKET                            20015050
      IF(PKT.NE.0) KEYS(PKT)=KEYS(PKT)+1                                20015060
      GOTO 200                                                          20015070
C                                                                       20015080
C-----PICK UP BOUND OR RHS OF PACKET                                    20015090
 150  IF(PKT.NE.0) GOTO 155                                             20015100
      BNDJ=BOUND(JPOS)                                                  20015110
      GOTO 156                                                          20015120
 155  BNDJ=RHS(PKT+M)                                                   20015130
 156  DO 160 J=1,M                                                      20015140
 160  GAMMA(J) = GAMMA(J)- AJ(JORG+J)*BNDJ                              20015150
 200  CONTINUE                                                          20015160
C                                                                       20015170
```

```
C-----COMPLETE BASIS WITH ARTIFICIALS                                  20015180
C-----COUNT LOGICALS IN JL                                             20015190
      JL=0                                                             20015200
      DO  210 I=1,M                                                    20015210
      IF(MOD(IBASIS(I),100).NE.J) JL=JL+1                              20015220
      IF( IBASIS(I)/100.NE.0 ) GOTO 210                                20015230
      IF(MOD(IBASIS(I),100) .NE.1) GOTO 205                            20015240
C-----MAKE A LOGICAL BASIC INSTEAD                                     20015250
      IBASIS(I)=100*JL+IBASIS(I)                                       20015260
      GOTO 210                                                         20015270
  205 CONTINUE                                                         20015280
      IBASIS(I)=100*(I+NT)+IBASIS(I)                                   20015290
  210 CONTINUE                                                         20015300
C-----ADD ARTIFICIALS NEEDED                                           20015310
      DO 220 I=1,M                                                     20015320
  220 DELTA(I)=0.0                                                     20015330
      DELTA(M)=1.0                                                     20015340
      DO 240 I=1,M                                                     20015350
      IF(IBASIS(I)/100.LE.NT) GOTO 240                                 20015360
C-----ONE NEEDED HOW I                                                 20015370
      DELTA(I)=1.0                                                     20015380
      IOPG=1                                                           20015390
      DO 230 J=1,M                                                     20015400
      ALPHA(J)= DOT(M,P(IOPG),DELTA)                                   20015410
  230 IOPG=IOPG+M                                                      20015420
      DELTA(I)=0.0                                                     20015430
      CALL PIVOT(I,P,ALPHA)                                            20015440
  240 CONTINUE                                                         20015450
C                                                                      20015460
C-----NOW USE P AND GAMMA TO GET SOLUTION TO BETA                      20015470
      CALL FEASCH(P)                                                   20015480
      RETURN                                                           20015490
      END                                                              20015500
```

```
      SUBROUTINE  IO(KOL, ALPHA, NAME)                                  20015510
C-----GUB VERSION--APRIL-20-1971                                        20015520
C-----WRITES TWO FILES OF A MATRIX TO DISC   IN  STRAIGHT OR PACKED FORM20015530
      COMMON /FILES/ IA1,IA2,IMAP                                       20015540
      COMMON /I/ M,L,MPL,MC,NT,ICOST,IC,IPHASE,JRHS,IPI                 20015550
      COMMON /ROWTYP/ IROWTP(101)                                       20015560
      COMMON /LIMS/ MAXTRY,NTRY,JNCORE,NCRMAX,NSCAN                     20015570
      COMMON /CORE/ JAREJ(101),JA(101),JAK(101),AJ(1000)                20015580
      DIMENSION ALPHA(1),ID(100),D(100)                                 20015590
      COMMON /B/ ALPHB(100)                                             20015600
      DATA ZERO/1.E-10/                                                 20015610
C                                                                       20015620
      ENTRY  OUT                                                        20015630
C----------------TO DISC FILES IA1/IA2                                  20015640
C                                                                       20015650
      IF (KOL.GT.1)  GOTO 10                                            20015660
      REWIND IA1                                                        20015670
      REWIND IA2                                                        20015680
      KOL1=KOL2=0                                                       20015690
C                                                                       20015700
C-----STRIP GUBS AND PACK  FOR TWO FILES                                20015710
 10   J=K=0                                                             20015720
      DO 20  I=1, M                                                     20015730
      IF( IROWTP(I).EQ.4 )  GOTO  20                                    20015740
      J=J+1                                                             20015750
      ALPHB(J)=ALPHA(I)                                                 20015760
      IF(ABS(ALPHA(I)).LT.ZERO) GOTO 2                                  20015770
      K=K+1                                                             20015780
      ID(K)=J                                                           20015790
      D(K)=ALPHA(I)                                                     20015800
 20   CONTINUE                                                          20015810
      NAME=KOL                                                          20015820
      WRITE(IA1) KOL,NAME,(ALPHB(I),I=1,J)                              20015830
      WRITE(IA2) KOL,NAME,K,(ID(I),D(I),I=1,K)                          20015840
      RETURN                                                            20015850
C                                                                       20015860
C                                                                       20015870
      ENTRY  IN                                                         20015880
C---------------FOR NORMAL COLUMNS FROM DISC IA1                        20015890
      DO 100 JNT=1,NT                                                   20015900
      IF(MOD(KOL1,NT).NE.0) GOTO 110                                    20015910
 99   REWIND IA1                                                        20015920
      REWIND IA2                                                        20015930
      NSCAN =1+NSCAN                                                    20015940
 110  READ(IA1) KOL1,NAAM,(ALPHA(I),I=1,M)                              20015950
      IF(KOL.LT.KOL1) GOTO 99                                           20015960
      IF(KOL.EQ.KOL1) GOTO 101                                          20015970
 100  CONTINUE                                                          20015980
      GOTO 300                                                          20015990
 101  CONTINUE                                                          20016000
C-----UPDATE RECORDS  AND TRACK  DISC LOCATION IN KOL                   20016010
 120  CONTINUE                                                          20016020
      JCOL=NAME                                                         20016030
      JA(JCOL)=KOL                                                      20016040
      JAK(JCOL)= NAAM                                                   20016050
      JAREJ(JCOL)=0                                                     20016060
      RETURN                                                            20016070
```

```
C                                                                       20016080
C                                                                       20016090
      ENTRY INPOS                                                       20016100
C-----TO GET THE INPUT FILE POSITION                                    20016110
      KOL=KOL1                                                          20016120
      RETURN                                                            20016130
C                                                                       20016140
C                                                                       20016150
      ENTRY INPCKD                                                      20016160
C-------------AUXILIARY FILE FOR KEYS                                   20016170
      DO 200 JNT=1,NT                                                   20016180
      IF( MOD(KOL2,NT).NE.0) GOTO 199                                   20016190
  195 REWIND IA2                                                        20016200
  199 READ(IA2) KOL2,NAAM,K,(ID(I),D(I),I=1,K)                          20016210
      IF(KOL.LT.KOL2) GOTO 195                                          20016220
      IF(KOL2.EQ.KOL) GOTO 201                                          20016230
  200 CONTINUE                                                          20016240
      GOTO 300                                                          20016250
  201 CONTINUE                                                          20016260
C-----UNPACK D TO ALPHA                                                 20016270
      DO 210 I=1,M                                                      20016280
  210 ALPHA(I)=0.                                                       20016290
      IF(K.EQ.0) GOTO 120                                               20016300
      DO 220 I=1,K                                                      20016310
      J=ID(I)                                                           20016320
  220 ALPHA(J)=D(I)                                                     20016330
      GOTO 120                                                          20016340
C                                                                       20016350
C-----TROUBLE                                                           20016360
  300 CALL ERROR (4CHIO--COLUMN NOT LOCATED IN NT READS          )      20016370
      CALL ESCAPE( 8 )                                                  20016380
      END                                                               20016390
```

```
      SUBROUTINE KEYCH(JCOL,IROW,B)                                     20016400
C------GUB VERSION APRIL/71                                             20016410
      COMMON /I/ M,L,MPL,MC,NT,ICOST,IC,IPHASE,JRHS,IPI                 20016420
      COMMON /BASIS/ IBASIS(101),KEYS(101)                              20016430
      COMMON /NAMES/ NAME(100)                                          20016440
      COMMON /A/ ALPHA(101) /B/ BETA(101) /C/ GAMMA(101) /D/ DELTA(101) 20016450
      REAL B(1)                                                         20016460
      NPKT(J)=MOD(NAME(J),100000)/10                                    20016470
      ITP(J)=MOD(IBASIS(J),100)                                         20016480
C                                                                       20016490
C-----INTERCHANGE KEY WITH FIRST BASIC COL IN KEYS PACKET               20016500
C     RETURNING ROW OF NEW BASIC COL (OLD KEY)                          20016510
      JCOLPK= NPKT(JCOL)                                                20016520
C-----FIRST BASIC COL                                                   20016530
      DO 10 I=1,M                                                       20016540
      JKEY  = IBASIS(I)/100                                             20016550
      IF(JKEY.GT.NT) GOTO 10                                            20016560
      IF(NPKT(JKEY).EQ.JCOLPK) GOTO 20                                  20016570
 10   CONTINUE                                                          20016580
      CALL ERROR(40HKEYCH--ESSENTIAL PACKET NO BASIC COL      )         20016590
      CALL ESCAPE                                                       20016600
C                                                                       20016610
C-----RE-DIFFERENCE BASIS INVERSE TO MAKE JKEY KEY                      20016620
 20   IROW = I                                                          20016630
      JORG = M*IROW-M                                                   20016640
      DO 30 J=1,M                                                       20016650
 30   B(JORG+J) =-B(JORG+J)                                             20016660
      IORG = 0                                                          20016670
      DO 50 I=1,M                                                       20016680
      IF(I.EQ.IROW) GOTO 50                                             20016690
      IB=IBASIS(I)/100                                                  20016700
      IF(IB.GT.NT) GOTO 50                                              20016710
      IF(NPKT(IB).NE.JCOLPK) GOTO 50                                    20016720
      DO 40 J=1,M                                                       20016730
 40   B(JORG+J)=B(JORG+J)-B(IORG+J)                                     20016740
 50   IORG=IORG+M                                                       20016750
C                                                                       20016760
C-----NEW KEY IS NOW JKEY                                               20016770
      CALL SETKEY(JKEY)                                                 20016780
      KEYS(JCOLPK)= 100*JKEY+ MOD(KEYS(JCOLPK),100)                     20016790
C-----COL JCOL IS NOW BASIC                                             20016800
      CALL SETBNB(JCOL)                                                 20016810
      IBASIS(IROW)=100*JCOL+ITP(IROW)                                   20016820
C-----REARRANGE SOLUTION                                                20016830
      MPK=M+JCOLPK                                                      20016840
      SUM=ALPHA(IROW)                                                   20016850
          ALPHA(IROW)=ALPHA(MPK)                                        20016860
                      ALPHA(MPK)=SUM                                    20016870
      SUM= BETA(IROW)                                                   20016880
           BETA(IROW)=BETA(MPK)                                         20016890
                      BETA(MPK)=SUM                                     20016900
      RETURN                                                            20016910
      END                                                               20016920
```

```
      FUNCTION KEYEND(PKT)                                              20016930
      COMMON /CORE/ JAREJ(101),JA(101),JAK(101),AJ(100)                 20016940
      COMMON /LIMS/ MAXTRY,NTRY,JNCORE,NCRMAX,NSCAN                     20016950
      COMMON /NAMES/ NAME(100)                                          20016960
      COMMON /BASIS/ IPASIS(101),KEYS(101)                              20016970
      INTEGER PKT                                                       20016980
      NPKT(I)=MOD(NAME(I),100000)/10                                    20016990
C                                                                       20017000
C-----GIVEN PACKET NO. PKT, FIND ITS KEY IN CORE                        20017010
      IF(PKT.EQ.0) GOTO 100                                             20017020
      KEY=KEYS(PKT)/100                                                 20017030
      DO  20 K=1,JNCORE                                                 20017040
      IF(JA(K).EQ.KEY) GOTO 30                                          20017050
 20   CONTINUE                                                          20017060
      KEYEND=0                                                          20017070
      RETURN                                                            20017080
 30   KEYEND=K                                                          20017090
      RETURN                                                            20017100
C                                                                       20017110
C-----FIND THE FIRST KEY WITH NO COLUMNS IN CORE FOR CHECK              20017120
 100  DO 130 K=1,JNCORE                                                 20017130
      JAK=JA(K)                                                         20017140
      JTYPE=MOD(NAME(JAK),10)                                           20017150
      IF(JTYPE.NE.4) GOTO 130                                           20017160
      JPKT=NPKT(JAK)                                                    20017170
      DO 120 J=1,JNCORE                                                 20017180
      JAJ=JA(J)                                                         20017190
      JTYPE=MOD(NAME(JAJ),10)                                           20017200
      IF(JTYPE.EQ.4) GOTO 120                                           20017210
      IF(JPKT.EQ.NPKT(JAJ)) GOTO 130                                    20017220
 120  CONTINUE                                                          20017230
      GOTO 30                                                           20017240
 130  CONTINUE                                                          20017250
      KEYEND=0                                                          20017260
      RETURN                                                            20017270
      END                                                               20017280
```

```
      SUBROUTINE MAPIN(B)                                               20017290
C-----SUB VERSION  APRIL 20/71                                          20017300
C-----ADDS SPECS FOR BOUND/BASIC/NULL/KEY VARIABLES AND INVERSE IF PRESE20017310
C-----OPTIONALLY CALLED BEFORE INVERT                                   20017320
      COMMON /STATE/ JPOS,IROW,JCOL,JOUT,ITRN,NREJ,NPIF,NDJS           20017330
      COMMON /BASIS/ IBASIS(101),KEYS(101)                              20017340
      COMMON /A/ ALPHA(101) /B/ BETA(101) /C/ GAMMA(101) /D/ DELTA(101) 20017350
      COMMON /I/ M,L,MPL,MC,NT,ICOST,IC,IPHASE,JRHS,IPI                 20017360
      COMMON /FILES/ IA1,IA2,IMAP                                       20017370
      COMMON /INPUT/INPUT,INPUTM,INPUTN                                 20017380
      COMMON /TOLS/ DJTOL,ZERO,PIVTOL,CTOL,PERTOL,DERTOL                20017390
      COMMON /NAMES/ NAME(100)                                          20017400
      COMMON /BOUNDS/ BOUNDS(100),IBDS(100),NBDS                        20017410
      COMMON /PARAMS/ TMAX,ITNINV,INVF,K1,K2,K3,K4,K5                   20017420
      REAL B(1)                                                         20017430
      DIMENSION CARD(8)                                                 20017440
      INTEGER NAMES(5)                                                  20017450
      INTEGER PKT                                                       20017460
      REAL NULL,KEE,INVERS                                              20017470
      DATA  BASIC/5HBASIC/,ATBND/5HATBND/,ENDER/5HEND  /,ROWS/4HROWS/   20017480
     +      ,NULL/4HNULL/, KEE/3HKEY/,INVERS/5HINVER/                   20017490
     +        ,REWIND/6HREWIND/                                         20017500
      ITP(J)=MOD(IBASIS(J),100)                                         20017510
      NPKT(I)= MOD(NAME(I),100000)/10                                   20017520
C-----SETS BASIC COLUMNS AND LOGICALS                                   20017530
      CALL MESSG(40HMAPIN                                    )          20017540
      REWIND IMAP                                                       20017550
 10   READ(IMAP ,11) TYPE1,TYPE2,(NAMES(J),J=1,4)                       20017560
 11   FORMAT(2A5,4I10)                                                  20017570
      IF(MOD(K3,3).EQ.0) WRITE(6,12) TYPE1,TYPE2,(NAMES(J),J=1,4)       20017580
 12   FORMAT(X,2A5,4I10)                                                20017590
      IF(TYPE1.EQ.BASIC)  GOTO 30                                       20017600
      IF(TYPE1.EQ.KEE)  GOTO  50                                        20017610
      IF(TYPE1.EQ.ATBND) GOTO 15                                        20017620
      IF(TYPE1.EQ.NULL)  GOTO 80                                        20017630
      IF(TYPE1.EQ.INVERS) GOTO 95                                       20017640
      IF(TYPE1.EQ.ENDER)  RETURN                                        20017650
      CALL ERROR(40HMAPIN--UNRECOGNIZED TYPE CARD IN DATA        )      20017660
      RETURN                                                            20017670
C                                                                       20017680
C-----ADD AT BOUND COLUMN SPECS                                         20017690
 15   DO 20 J=1,4                                                       20017700
      ID=NAMES(J)                                                       20017710
      IF(ID.EQ.0) GOTO 20                                               20017720
      ID=ID+MC                                                          20017730
      BNDJ=BOUND(ID)                                                    20017740
      IF(BNDJ.LT.1.E8)  GOTO 19                                         20017750
      CALL ERROR(40HMAPIN--ATBND COLUMN NOT BOUNDED IBDS/BDS     )      20017760
      CALL DUMP(IBDS(1),IBDS(NBDS),2,BOUNDS(1),BOUNDS(NBDS),1)          20017770
      GOTO 20                                                           20017780
 19   CONTINUE                                                          20017790
      CALL SETBND(ID)                                                   20017800
 20   CONTINUE                                                          20017810
      GOTO 10                                                           20017820
C                                                                       20017830
C-----BASIC COLUMNS ADDED                                               20017840
 30   IF(TYPE2.EQ.ROWS) GOTO 60                                         20017850
```

```
      DO 40 J=1,4                                                       20017850
      ID=NAMES(J)                                                       20017870
      IF(ID.EQ.0) GOTO 40                                               20017880
      ID=ID+MC                                                          20017890
      CALL SETBNB(ID)                                                   20017900
 40   CONTINUE                                                          20017910
      GOTO 10                                                           20017920
C                                                                       20017930
C-----ENTER KEY COLUMNS IF A SUB PROBLEM                                20017940
 50   IF(L.EQ.0) GOTO 30                                                20017950
      DO 55 I=1,4                                                       20017960
      ID=NAMES(I)                                                       20017970
      IF ( ID.EQ.0 ) GOTO  10                                           20017980
      ID=ID+MC                                                          20017990
      PKT=NPKT(ID)                                                      20018000
      IF(PKT.EQ.0) GOTO 55                                              20018010
      JOUT=KEYS(PKT)/100                                                20018020
      IF(JOUT.NE.0) CALL SETKEY(-JOUT)                                  20018030
      CALL SETKEY(ID)                                                   20018040
      KEYS(PKT)=100*ID                                                  20018050
 55   CONTINUE                                                          20018060
      GOTO 10                                                           20018070
C                                                                       20018080
C-----BASIC ROW-COL DATA FOR ENTRY OF ROW LOGICALS                      20018090
 60   DO 70 J=1,4                                                       20018100
      ID=NAMES(J)                                                       20018110
      IF(ID.EQ.0)GOTO 70                                                20018120
      CALL SETBNB(ID)                                                   20018130
 70   CONTINUE                                                          20018140
      GOTO 10                                                           20018150
C                                                                       20018160
C-----SET NULL COLUMNS                                                  20018170
 80   DO 90 J=1,4                                                       20018180
      ID=NAMES(J)                                                       20018190
      IF(ID.EQ.0) GOTO 90                                               20018200
      ID=ID+MC                                                          20018210
      CALL SETNNN(ID)                                                   20018220
 90   CONTINUE                                                          20018230
      GOTO 10                                                           20018240
C                                                                       20018250
C-----CHECK FOR INVERSE AT END OF INPUT TAPE OR SKIP                    20018260
 95   MM=M*M                                                            20018270
      READ(INPUT) (B(J),J=1,MM)                                         20018280
      IF(ENDFILE INPUT) 10,96                                           20018290
 96   READ(INPUT) (IBASIS(J),BETA(J),J=1,M)                             20018300
      IF(ENDFILE INPUT) 10,97                                           20018310
 97   IF(L.NE.0) READ(INPUT) (KEYS(J),BETA(J+M),J=1,L)                  20018320
      IF(ENDFILE INPUT) 10,98                                           20018330
C-----SUCCESSFULL, SUPPRESS INVERT                                      20018340
 98   ITHINV=INVF/2                                                     20018350
      CALL MSSG(40HSTARTED FROM GIVEN INVERSE ON INPUT          )       20018360
C-----RESET INPUT FILE FOR MAPOUT TO OVERWRITE LAST INVERSE             20018370
      BACKSPACE INPUT                                                   20018380
      BACKSPACE INPUT                                                   20018390
      IF(L.EQ.0) GOTO 10                                                20018400
      BACKSPACE INPUT                                                   20018410
      GOTO 10                                                           20018420
C                                                                       20018430
```

```
C
      ENTRY INMAP                                                        20018440
C-----READS MAP CARDS FROM INPUT TO FILE IMAP AND TERMINATES THEM        20018450
      CALL MSSG(40HINMAP LOOKED FOR  MAP                    )           20018460
      DO 200 I=1,1000                                                    20018470
      READ(5,2) CARD                                                     20018480
      IF(ENDFILE 5) 201,199                                              20018490
 199  CONTINUE                                                           20018500
 2    FORMAT(8A10)                                                       20018510
      IF (CARD(1).EQ.ENDER) GOTO 201                                     20018520
      IF(CARD(1).EQ.REWIND)  GOTO 202                                    20018530
      WRITE(IMAP,2) CARD                                                 20018540
 1999 CONTINUE                                                           20018550
 200  CONTINUE                                                           20018560
C-----ENDS THE MAPOUT CARDS                                             20018570
 201  WRITE(IMAP,2)  ENDER                                               20018580
      RETURN                                                             20018590
 202  REWIND IMAP                                                        20018600
      CALL MESSG(40HINMAP--DELETED EXISTING MAP,  IF ANY          )      20018610
      GOTO 1999                                                          20018620
      END                                                                20018630
                                                                         20018640
```

```
      SUBROUTINE MAPOUT(B)                                                      20018650
C-----SUB VERSION  APRIL-20-71                                                  20018660
C-----OUTPUTS THE FINAL BASIS FOR MAPIN USE                                     20018670
C                                                                               20018680
      COMMON /NAMES/ NAME(100)                                                  20018690
      COMMON /BASIS/ . ASIS(101),KEYS(101)                                      20018700
      COMMON /A/ ALPHA(101) /B/ BETA(101) /C/ GAMMA(101) /D/ DELTA(101)         20018710
      COMMON/IXX/IX(100) /XX/ X(100)                                            20018720
      COMMON /INPUT/INPUT,INPUTM,INPUTN                                         20018730
      COMMON /FILES/ IA1,IA2,IMAP                                               20018740
      COMMON /I/ M,L,MP1,MC,NT,ICOST,IC,IPHASE,JRHS,IPI                         20018750
      COMMON /LIMS/ MAXTRY,NTRY,JNCORE,NCPMAX                                   20018760
      COMMON /CORE/ JAREJ(101),JA(101),JAK(101),AJ(1000)                        20018770
      COMMON /PARAMS/ TMAX,ITNINV,TNVE,K1,K2,K3,K4,K5                           20018780
      COMMON /BOUNDS/ BOUNDS(100),IBDS(100),NBDS                                20018790
      EQUIVALENCE (MAPKEY,AJ)                                                   20018800
      DIMENSION MAPBAS(100),MAP BND(10 ),MAPNLL(10),MAPKEY(1000)                20018810
      REAL B(1)                                                                 20018820
C                                                                               20018830
      CALL MESSG(40HMAPOUT                                          )           20018840
      REWIND IMAP                                                               20018850
      JNCORE=0                                                                  20018860
      DO 50 I=1,MC                                                              20018870
      IF(NAME(I).NE.2) GOTO 50                                                  20018880
      WRITE(IMAP,1) I                                                           20018890
 1    FORMAT(10HBASICROWS  ,I10)                                                20018900
 50   CONTINUE                                                                  20018910
C                                                                               20018920
      K=INLL=IBND=IBAS=IKEY=0                                                   20018930
C-----CLEAR SOLUTION SPACE                                                      20018940
      NVARS=INPUTM+NBDS                                                         20018950
      DO 60 I=1,NVARS                                                           20018960
      IX(I)=0                                                                   20018970
 60   X(I)=0.                                                                   20018980
      MP1=MC+1                                                                  20018990
      DO 40 I=MP1,NT                                                            20019000
      JCOL=I-MC                                                                 20019010
      J=MOD(NAME(I),10)+1                                                       20019020
      GOTO(10,40,20,30,35),J                                                    20019030
C                                                                               20019040
 10   INLL=INLL+1                                                               20019050
      MAPNLL(INLL)=JCOL                                                         20019060
      GOTO 40                                                                   20019070
 20   IBAS=IBAS+1                                                               20019080
      MAPBAS(IBAS)=JCOL                                                         20019090
      DO 25 IP=1,M                                                              20019100
      IF(IBASIS(IP)/100.EQ.I) GOTO 26                                           20019110
 25   CONTINUE                                                                  20019120
 26   K=K+1                                                                     20019130
      IX(K)=JCOL                                                                20019140
      X(K)=BETA(IP)                                                             20019150
      GOTO 40                                                                   20019160
 30   IBND=IBND+1                                                               20019170
      MAPBND(IBND)=JCOL                                                         20019180
      K=K+1                                                                     20019190
      IX(K)=JCOL                                                                20019200
      X(K)=BOUND(I)                                                             20019210
```

```
      GOTO 40                                                          20019220
 35   IKEY=IKEY+1                                                      20019230
      MAPKEY(IKEY)=JCOL                                                20019240
      DO 36 IR=1,L                                                     20019250
      IF(KEYS(IR)/100.EQ.I) GOTO 37                                    20019260
 36   CONTINUE                                                         20019270
 37   K=K+1                                                            20019280
      IX(K)=JCOL                                                       20019290
      X(K)=BETA(IR+M)                                                  20019300
 40   CONTINUE                                                         20019310
      IF(IBAS.NE.0) WRITE(IMAP,2) (MAPBAS(I),I=1,IBAS)                 20019320
      IF(IBND.NE.0) WRITE(IMAP,3) (MAPBND(I),I=1,IBND)                 20019330
      IF(INLL.NE.0) WRITE(IMAP,4) (MAPNLL(I),I=1,INLL)                 20019340
      IF(IKEY.NE.0) WRITE(IMAP,6) (MAPKEY(I),I=1,IKEY)                 20019350
 2    FORMAT(10HBASIC     ,4I10)                                       20019360
 3    FORMAT(10HATBND     ,4I10)                                       20019370
 4    FORMAT(10HNULL      ,4I10)                                       20019380
 5    FORMAT(10HEND          )                                         20019390
 6    FORMAT(10HKEY       ,4I10)                                       20019400
 7    FORMAT(10HINVERSE      )                                         20019410
      IF(MOD(K3,2).NE.0) GOTO 598                                      20019420
C-----PLACE BASIS ON END OF INPUT TAPE, AFTER ANY THERE ALREADY        20019430
      MM=M*M                                                           20019440
      WRITE(INPUT) (B(I),I=1,MM)                                       20019450
      WRITE(INPUT) (IBASIS(J),BETA(J),J=1,M)                           20019460
      IF(L.NE.0) WRITE(INPUT) (KEYS(J),BETA(J+M),J=1,L)                20019470
      WRITE(IMAP,7)                                                    20019480
 598  WRITE(IMAP,5)                                                    20019490
 599  IF(MOD(K3,5).NE.0) RETURN                                        20019500
 600  WRITE(6,601)                                                     20019510
 601  FORMAT(*0CURRENT SOLUTION*/*0       BASIS       VALUE        -PI*)20019520
      WRITE(6,602) (IBASIS(I),BETA(I),B(IPI+I-1),I=1,M)                20019530
 602  FORMAT(I12,2E12.4)                                               20019540
      WRITE(6,603) (KEYS(I),BETA(I+M),I=1,L)                           20019550
 603  FORMAT(*0        KEYS       VALUE*/(I12,E12.4))                  20019560
      WRITE(6,604) (IX(I),X(I),I=1,K)                                  20019570
 604  FORMAT(*0SOLUTION VECTOR, PACKED*/(I12,E12.4))                   20019580
C-----PRICE OUT REMAINING VECORS                                       20019590
      WRITE(6,701)                                                     20019600
 701  FORMAT(*0REMAINING VECTORS*)                                     20019610
      DO 700 J=MP1,NT                                                  20019620
      JTYPE=MOD(NAME(J),10)                                            20019630
      IF(JTYPE.EQ.2) GOTO 700                                          20019640
      CALL IN(J,GAMMA,1)                                               20019650
      DJVAL=DOTS(M,B(IPI),GAMMA)                                       20019660
      WRITE(6,702) J,DJVAL,NAME(J)                                     20019670
 702  FORMAT(I12,12X,E12.4,I12 )                                       20019680
 700  CONTINUE                                                         20019690
      RETURN                                                           20019700
      END                                                              20019710
```

```
      SUBROUTINE PIVOT(IROW,B,ALPHA)                                    20019720
C-----PIVOT ALPHA INTO B ROW IROW                                       20019730
      COMMON /NAMES/ NAME(100)                                          20019740
      COMMON /BASIS/ IBASIS(101),KEYS(101)                              20019750
      COMMON /STATE/ JROS                                               20019760
      COMMON /T/ M,L,MPL,MC,NT,ICOST,IC,IPHASE,JRHS,IPI                 20019770
      COMMON /TOLS/ DJTOL,ZERO,PIVTOL,CTOL,PERTOL,DEPTOL                20019780
      COMMON /PARAMS/ TMAX,ITNINV,INVF,K1,K2,K3,K4,K5                   20019790
      REAL ALPHA(1),B(1)                                                20019800
      NPKT(I)=MOD(NAME(I),100000)/10                                    20019810
C                                                                       20019820
C-----CHECK ALPHA HAS A ROW                                             20019830
      IF(IROW.EQ.0) GOTO 90                                             20019840
C-----NORMALISE ROW  IROW                                               20019850
 1    CONTINUE                                                          20019860
      IORG=M*(IROW-1)                                                   20019870
      PIV=1.                                                            20019880
      IF (ALPHA(IROW).EQ.1.0)  GOTO   20                                20019890
      IF( ABS(ALPHA(IROW) ).GT.PIVTOL) GOTO 5                           20019900
      CALL ERROR(40HPIVOT--PIVOT LESS THAN PIVTOL                )      20019910
      CALL ESCAPE(8)                                                    20019920
 5    PIV   = 1.0/ALPHA(IROW)                                           20019930
      DO 10 I=1,M                                                       20019940
 10   B(IORG+I)= B(IORG+I)*PIV                                          20019950
C-----PIVOT ON FOR ROW I,  LEAVE  ALPHA.                                20019960
 20   DO 30 I=1,M                                                       20019970
      IF( I.EQ.IROW) GOTO 30                                            20019980
      IF( ABS( ALPHA(I)).LT.ZERO) GOTO 30                               20019990
      JORG=M*(I-1)                                                      20020000
      PIV=ALPHA(I)                                                      20020010
      DO 25 J=1,M                                                       20020020
 25   B(JORG+J)=B(JORG+J)-PIV *B(IORG+J)                                20020030
 30   CONTINUE                                                          20020040
      RETURN                                                            20020050
C                                                                       20020060
C-----FIND BEST ROW TO PIVOT ALPHA INTO B                               20020070
 90   CONTINUE                                                          20020080
      PIV=PIVTOL                                                        20020090
      DO 100 I=1,M                                                      20020100
C-----CHECK FOR FREE LOGICALS                                           20020110
      JP=IBASIS(I)/100                                                  20020120
      IF(JP.NE.JROS) GOTO 99                                            20020130
      IROW=I                                                            20020140
      GOTO 1                                                            20020150
 99   IF(JP.NE.0) GOTO 100                                              20020160
C-----ZERO BASIS ENTRY AT I                                             20020170
      DIVOT=ABS(ALPHA(I))                                               20020180
      IF(DIVOT.LT.PIV) GOTO 100                                         20020190
      PIV=DIVOT                                                         20020200
      IROW=I                                                            20020210
 100  CONTINUE                                                          20020220
      IF(IROW.EQ.0) GOTO 150                                            20020230
C-----BEST ROW TO ADD THIS COLUMN IS IROW                               20020240
 101  CONTINUE                                                          20020250
      IBASIS(IROW)=100*JROS+IBASIS(IROW)                                20020260
      GOTO 1                                                            20020270
C-----THE COLUMN IS NO GOOD ANYWHERE AT PRESENT, DROP FROM BASIC SET    20020280
```

```
150   CONTINUE
      CALL SETBNB(-JPOS)
      IF(MOD(K3,13).NE.0) RETURN
      WRITE(6,151)  JPOS
151   FORMAT(1H ,*PIVOT DROPPED COLUMN* I6     )
      RETURN
      END
```

```
      SUBROUTINE PRIMAL(B)                                                  20020360
C------GUB VERSION APRIL/71                                                20020370
      COMMON  /MOVES/ THETA,BNDJ,DMAX,PRMLER,DUALER                         20020380
      COMMON /TOLS/ OJTOL,ZERO,PIVTOL,CTOL,PERTOL,DERTOL                    20020390
      COMMON /STATE/ JPOS,IROW,JCOL,JOUT,ITRN,NREJ,NDTF,NDJS                20020400
      COMMON /PARAMS/ TMAX,ITNINV,INVF,K1,K2,K3,K4,K5                       20020410
      COMMON /LIMS/ MAXTRY,NTRY,JNCORE,NCRMAX,NSCAN                         20020420
      COMMON /CORE/ JAPFJ(101),JA(101),JAK(101),AJ(1000)                    20020430
      COMMON /I/ M,L,MPL,MC,NT,ICOST,IC,IPHASE,JRHS,IPI                     20020440
      COMMON /A/ ALPHA(101) /B/ BETA(1 1) /C/ GAMMA(101) /D/ DELTA(101)     20020450
      COMMON /BASIS/ IBASIS(101),KEYS(101)                                  20020460
      COMMON /DJS/ DJ(100)                                                  20020470
      COMMON /NAMES/ NAME(100)                                              20020480
      COMMON /RHS/ RHS(100)                                                 20020490
      REAL B(1)                                                             20020500
      LOGICAL BASIC,ATBND                                                   20020510
      ITP(I)=MOD(IBASIS(I),10)                                              20020520
      ATBND(I)=MOD(NAME(I),10).EQ.3                                         20020530
      NBKT(J)=MOD(NAME(J),100000)/10                                        20020540
C                                                                           20020550
      CALL MESSG(4HPRIMAL                                       )           20020560
C                                                                           20020570
      IROW=JCOL=NREJ=NDEG=0                                                 20020580
      CALL STATUS(40HPRIMAL--BEGIN                              )           20020590
 3000 CONTINUE                                                              20020600
C-----FIND THE COST ROW                                                     20020610
      IC=ICOST                                                              20020620
      IF ( IPHASE.EQ.1 )  IC= M                                             20020630
C-----KEEP PHASE1 COST ZERO IN PHASE 2                                      20020640
C-----PHASE 1 COST IS FREE IN PHASE 1                                       20020650
      IBASIS(M)=100*(IBASIS(M)/100)                                         20020660
      IF(IPHASE.EQ.1) IBASIS(M)=IBASIS(M)+3                                 20020670
C-----PICK UP NEW PI                                                        20020680
      IPI=1+M*IC-M                                                          20020690
C-----CUTOFF FOR DEGENERACY REJECTS                                         20020700
      NDEGLM=0                                                              20020710
C                                                                           20020720
C*****BASIC CYCLE OF 2 PHASE LP***********                                  20020730
 1    ITRN=1+ITRN                                                           20020740
      THETA=BNDJ=IROW=JCOL=JOUT=JPOS=0                                      20020750
C                                                                           20020760
C-----LOCATE PIVOTAL COLUMN                                                 20020770
 30   CALL COLUMN( JCOL,B)                                                  20020780
      IF( JCOL.NE.0)  GOTO 50                                               20020790
      CALL XCHECK(6HPRIMAL,44QUIT,B)                                        20020800
C                                                                           20020810
C-----OPTIMUM, CHECK MODE  = PHASE1/ PHASE2/ NOFEAS                         20020820
      IF( IPHASE.EQ.2)  GOTO 2000                                           20020830
      IF(  ABS(BETA(IC)).LT.CTOL) GOTO 1000                                 20020840
      CALL  NO FEAS                                                         20020850
      RETURN                                                                20020860
C                                                                           20020870
C-----STEP PROCEDURE FOR  IN CORE COLUMN  JCOL                              20020880
 50   CONTINUE                                                              20020890
C-----LOCATE COLUMN  POSITION AND BOUND                                     20020900
      JPOS = JA(JCOL)                                                       20020910
      BNDJ = BOUND(JPOS)                                                    20020920
```

```
C                                                                       20020930
C-----LOCATE PIVOTAL ROW IROW AND STEP THETA                            20020940
      CALL  ROW(THETA, IROW, JCOL, ITYPE,B)                             20020950
      IF( IROW.NE.0)  GOTO 60                                           20020960
      CALL XCHECK(6HPRIMAL,4HQUIT,B)                                    20020970
      CALL UNBND                                                        20020980
      RETURN                                                            20020990
C                                                                       20021000
C                                                                       20021010
C-----DEGENERACY AND PIVOT CHECKS                                       20021020
 60   IF( ABS(ALPHA(IROW)).GE.PIVTOL)  GOTO 65                          20021030
      IF(NREJ.LT.2) GOTO 62                                             20021040
      WRITE(6,61) JA(JCOL),IROW, ALPHA(IROW),BETA(IROW)                 20021050
 61   FORMAT(20X,*REJECTED COLUMN*I5*  ROW*I5*  PIVOT*E12.4*  RHS*E12.4)20021060
 62   CONTINUE                                                          20021070
      JAREJ(JCOL)=1                                                     20021080
      NREJ = 1+NREJ                                                     20021090
      IF(NREJ.NE.5) GOTO 64                                             20021100
C-----RE-INVERT, CLEAR REJECTS AND CONTINUE                             20021110
      ITNINV=ITRN                                                       20021120
      CALL INVERT(B)                                                    20021130
      DO 63 J=1,JNCORE                                                  20021140
 63   JAREJ(J)=0                                                        20021150
 64   CONTINUE                                                          20021160
      IF(NREJ.LT.100) GOTO 30                                           20021170
      CALL ERROR(40HPRIMAL--TOO MANY REJECT VECTORS          )          20021180
C-----TRY ENDING IF PHASE 2                                             20021190
      IF(IPHASE.EQ.2) GOTO 2000                                         20021200
      CALL ESCAPE(B)                                                    20021210
C                                                                       20021220
 65   IF( ABS(THETA*DJ(JCOL)).GE.CTOL) GOTO 70                          20021230
      IF(NDJS.EQ.1) GOTO 70                                             20021240
      IF(NDEG.GE.NDEGLM) GOTO 70                                        20021250
      NDEG=1+NDEG                                                       20021260
      JAREJ(JCOL)=1                                                     20021270
      GOTO 30                                                           20021280
C                                                                       20021290
C-----CHECK EXCEED BOUND ON JPOS---- XJPOS MOVES TO OR OFF  BOUND       20021300
 70   CONTINUE                                                          20021310
      CALL XCHECK(6HPRIMAL,3HEND,B)                                     20021320
      IF( ABS(THETA)+ZERO.LT.BNDJ)  GOTO 80                             20021330
      ITYPE=1                                                           20021340
C-----SUPPRESS PRICING NEXT TIME                                        20021350
      NREJ=1                                                            20021360
C-----JOUT=0 KILLS STATUS PRINT                                         20021370
      JOUT=0                                                            20021380
      IF(THETA.GE.0.0) GOTO 75                                          20021390
C-----XJPOS COMES OFF BOUND , THETA NEG.                                20021400
      CALL SETBND(  -JPOS  )                                            20021410
      THETA= - BNDJ                                                     20021420
      GOTO 90                                                           20021430
C-----XJPOS GOES TO BOUND                                               20021440
 75   CALL SETBND( JPOS)                                                20021450
      THETA = BNDJ                                                      20021460
      GOTO  90                                                          20021470
C                                                                       20021480
C-----PICK UP REJECTED COL, C      OR KEY CHANGE                        20021490
 80   CONTINUE                                                          20021500
```

```
      JOUT=IBASIS(IROW)/100                                                    20021510
      IF(IROW.LE.M) GOTO  800                                                  20021520
C-----KEY CHANGE, CORRECT REJECTED COL AND CHECK ESSENTIL PACKET                20021530
      JOUT=KEYS(IROW-M)/100                                                    20021540
      NBVPKT=MOD( KEYS(IROW-M),100)                                            20021550
      IF(NBVPKT.GT.0)GOTO  81                                                  20021560
C-----CHANGE KEY FROM JOUT TO JPOS IN NON-ESSENTIAL PKT                        20021570
      KEYS(IROW-M) = 100*JPOS                                                  20021580
      CALL SET KEY(JPOS)                                                       20021590
      CALL SET KEY(-JOUT)                                                      20021600
C-----SET PARAMS FOR KEY STEP                                                  20021610
      EPSI=THETA                                                               20021620
C-----SUPPRESS PRICING NEXT TIME                                               20021630
      NREJ=1                                                                   20021640
      GOTO  90                                                                 20021650
C                                                                              20021660
C-----ESSENTIAL PACKET, CHANGE JOUT FROM KEY TO BASIC IN NEWROW                20021670
 81   CALL KEY CH(JOUT,NEWROW,B)                                               20021680
      IROW = NEWROW                                                            20021690
C                                                                              20021700
C-----NORMAL PIVOT OPERATION                                                   20021710
 800  CALL PIVOT(IROW,B, ALPHA )                                               20021720
C-----UPDATE KEY BASIS COUNTS FOR JPOS AND JOUT                                20021730
      JPOSPK=NPKT(JPOS)                                                        20021740
      IF(JPOSPK.EQ.0) GOTO  82                                                 20021750
      KEYS(JPOSPK)= KEYS(JPOSPK)+1                                             20021760
 82   JOUTPK=NPKT(JOUT)                                                        20021770
      IF(JOUT.GT.NT) GOTO 84                                                   20021780
      IF(JOUTPK.EQ.0) GOTO  84                                                 20021790
      KEYS(JOUTPK)= KEYS(JOUTPK)-1                                             20021800
 84   CONTINUE                                                                 20021810
C                                                                              20021820
C-----CHECK JPOS COMING OFF A BOUND (THETA.LE.0 )                              20021830
      EPSI=THETA                                                               20021840
      IF(ATBND(JPOS))  EPSI=BNDJ+THETA                                         20021850
C                                                                              20021860
C-----CHECK JOUT, MARK NEW AND UNMARK OLD BASIC COLS                           20021870
      JOUT = IBASIS( IROW )/100                                                20021880
      IBASIS(IROW) = 100*JPOS+MOD(IBASIS(IROW),100)                            20021890
      CALL SETBNB( JPOS)                                                       20021900
      CALL SETBNB(-JOUT)                                                       20021910
C-----ITYPE=2  IMPLIES JOUT OFF BOUND,  =3  IMPLIES  JOUT  TO BOUND            20021920
      IF(ITYPE.EQ.3) CALL SETBND(JOUT)                                         20021930
C-----RELEASE REJECTED VECTORS AFTER A PIVOT                                   20021940
      IF(NREJ+NDEG.EQ.0) GOTO 90                                               20021950
      NREJ=NDEG=0                                                              20021960
      DO 85 I=1,JNCORE                                                         20021970
C                                                                              20021980
C                                                                              20021990
C-----STEP BETA AND CONDITION COMPLETE PROBLEM  (OUR ROWS ARE LAST)             20022000
 85   JAREJ(I)=0                                                               20022010
 90   DO  100 I=1,MPL                                                          20022020
      BETA(I)=BETA(I)-THETA*ALPHA(I)                                           20022030
 100  CONTINUE                                                                 20022040
      IF(ITYPE.NE.1) BETA(IROW)= EPSI                                          20022050
      DO 110 I=1,M                                                             20022060
      IF(ITP(I).EQ.3) GOTO 110                                                 20022070
      IF(BETA(I).GE.0.0) GOTO 110                                              20022080
```

```
      BETA(I)=0.0                                                    20022090
  110 CONTINUE                                                       20022100
      DO 120 I=1,L                                                   20022110
      IF(BETA(I+M).GE.0.0) GOTO 120                                  20022120
      BETA(I+M)=0.0                                                  20022130
  120 CONTINUE                                                       20022140
      CALL STATUS(40HEND OF PRIMAL                        )          20022150
      GOTO 1                                                         20022160
C*****END OF BASIC PRIMAL CYCLE*****************                    20022170
C                                                                    20022180
C-----OPTIMUM PHASE1 TERMINATION                                     20022190
 1000 CONTINUE                                                       20022200
      CALL OPT1                                                      20022210
      IPHASE=2                                                       20022220
      BETA(M)=0.0                                                    20022230
      GOTO 3000                                                      20022240
C                                                                    20022250
C-----OPTIMUM PHASE2 TERMINATION                                     20022260
 2000 CONTINUE                                                       20022270
      CALL OPT2                                                      20022280
C                                                                    20022290
      RETURN                                                         20022300
      END                                                            20022310
```

```
      SUBROUTINE  ROW(THETA,IROW,JCOL,ITYPE,B)                          20022320
C-----SUB VERSION  APRIL 27/71                                          20022330
C-----FINDS STEP TO BOUND AND BOUND ENCOUNTERED                         20022340
      COMMON /I/ M,L,MPL,MC,NT,ICOST,IC,IPHASE,JPHS,IPI                 20022350
      COMMON /CORE/ JAREA(101),JA(1)1),JAK(1,1),AJ(1000)                20022360
      COMMON /BASIS/ IBASIS(101),KEYS(101)                              20022370
      COMMON /NAMES/ NAME(100)                                          20022380
      COMMON /A/ ALPHA(101) /B/ BETA(1,1) /C/ GAMMA(101) /D/ DELTA(101) 20022390
      COMMON /TOLS/ DJTOL,ZERO,PIVTOL,CTOL,REDTOL,DEPTOL                20022400
      LOGICAL BASIC,ATBND                                               20022410
      REAL B(1)                                                         20022420
      ITP(J)=MOD(IBASIS(J),100)                                         20022430
      NPKT(J)=MOD(NAME(J),100000)/10                                    20022440
      ATBND(I)=MOD(NAME(I),10).EQ.7                                     20022450
C                                                                       20022460
C-----TRANSFORM SELECTED COLUMN                                         20022470
      JPOS= JA(JCOL)                                                    20022480
C-----LOAD  COLUMN  TO DELTA (MAYBE NULL PACKET)                        20022490
      JORG= M*JCOL-M                                                    20022500
      DO 5  I=1,M                                                       20022510
 5    DELTA(I)= AJ(JORG+I)                                              20022520
C-----NULL ELEMENTS IN LOWER ALPHA FOR PACKET ROWS                      20022530
      DO 6  I=1,L                                                       20022540
 6    ALPHA(I+M)=0.                                                     20022550
C-----PACKET ROW HAS A UNITY                                            20022560
      JPKT= NPKT(JPOS)                                                  20022570
      IF (JPKT.EQ.0)  GOTO 16                                           20022580
      ALPHA(JPKT+M)=1.                                                  20022590
C-----FIND KEY AND KORG                                                 20022600
      KORG=KEYFND(JPKT)                                                 20022610
      IF(KORG.NE.0) GOTO 14                                             20022620
      CALL ERROR(4HROW--KEY NOT IN CORE                 )               20022630
      WRITE(6,998)JPKT,JCOL,JPOS                                        20022640
 998  FORMAT(1H+,40X,*PACKET*I5*  POSITION*I5*  COLUMN*I5)              20022650
      CALL ESCAPE(B)                                                    20022660
      IROW=0                                                            20022670
      RETURN                                                            20022680
 14   CONTINUE                                                          20022690
      KORG=M*KORG-M                                                     20022700
      DO 15 I=1,M                                                       20022710
 15   DELTA(I)=DELTA(I)-AJ(KORG+I)                                      20022720
C-----TRANSFORM REDUCED  COLUMN  IN LOWER ALPHA                         20022730
 16   IORG=1                                                            20022740
      DO 20 I=1,M                                                       20022750
      ALPHA(I)  = DOT( M, B(IORG), DELTA)                               20022760
 20   IORG=IORG+M                                                       20022770
C-----SUM PACKET BASIC ENTRIES TO  ALPHA ELEMENTS                       20022780
      IF(L.EQ.0) GOTO 26                                                20022790
      DO  25 I=1,M                                                      20022800
      IB = IBASIS(I)/100                                                20022810
      IF(IB.GT.NT) GOTO 25                                              20022820
      K= NPKT( IB )                                                     20022830
      IF(K.EQ.0) GOTO 25                                                20022840
      K=K+M                                                             20022850
      ALPHA(K)=ALPHA(K)-ALPHA(I)                                        20022860
 25   CONTINUE                                                          20022870
 26   CONTINUE                                                          20022880
```

```
C                                                                       20022890
      THETA=1.E35                                                       20022900
      IROW = 0                                                          20022910
      ITYPE= 1                                                          20022920
C                                                                       20022930
      IF(  ATBND(JPOS) )  GOTO 100                                      20022940
C                                                                       20022950
C-----X(JPOS) ZERO,  DJ  NEGATIVE ---INCREASE   X(JPOS)                 20022960
      DO  50 I=1,MPL                                                    20022970
      IF(I.LE.M .AND. ITP(I).EQ.3) GOTO 50                              20022980
      IF (  ALPHA(I).LT.-ZERO)   GOTO  30                               20022990
      IF (  ALPHA(I).GT. ZERO)   GOTO  10                               20023000
      GOTO 50                                                           20023010
C-----POSITIVE PIVOT                                                    20023020
 10   STEP  = BETA(I)/ALPHA(I)                                          20023030
      IF(  STEP .GE. THETA )  GOTO   50                                 20023040
      THETA = STEP                                                      20023050
      IROW  = I                                                         20023060
      ITYPE = 2                                                         20023070
      GOTO  50                                                          20023080
C-----NEGATIVE PIVOT-----(  BOUND(JOUT).GE.BETA(I) )                    20023090
 30   JOUT  =  IBASIS(I)/100                                            20023100
      IF(I.GT.M) JOUT=KEYS(I-M)/100                                     20023110
      STEP  =  ( BETA(I) - BOUND(JOUT) ) /  ALPHA(I)                    20023120
      IF(  STEP .GE. THETA )  GOTO   5                                  20023130
      THETA =  STEP                                                     20023140
      IROW  =  I                                                        20023150
      ITYPE =  3                                                        20023160
 50   CONTINUE                                                          20023170
      GOTO  200                                                         20023180
C                                                                       20023190
C-----X(JPOS) AT BOUND   DJ POS.--DECREASE  X(JPOS)                     20023200
 100  DO 150  I=1,MPL                                                  20023210
      IF(I.LE.M .AND. ITP(I).EQ.3) GOTO 150                             20023220
      IF(  ALPHA(I).LT. - ZERO )    GOTO 130                            20023230
      IF(  ALPHA(I).GT.   ZERO )    GOTO 110                            20023240
      GOTO  150                                                         20023250
C-----POSITIVE PIVOT----(  BOUND(JOUT).GE. BETA(I) )                    20023260
 110  JOUT =  IBASIS(I)/100                                             20023270
      IF(I.GT.M) JOUT=KEYS(I-M)/100                                     20023280
      STEP= (  BETA(I)-BOUND(JOUT) )/(-ALPHA(I))                        20023290
      IF( STEP. GE . THETA  )   GOTO  150                               20023300
      THETA = STEP                                                      20023310
      IROW  = I                                                         20023320
      ITYPE = 3                                                         20023330
      GOTO    150                                                       20023340
C-----NEGATIVE PIVOT                                                    20023350
 130  STEP=  BETA(I)/( -ALPHA(I) )                                      20023360
      IF( STEP  .GE. THETA)     GOTO  150                               20023370
      THETA=  STEP                                                      20023380
      IROW =  I                                                         20023390
      ITYPE=  2                                                         20023400
 150  CONTINUE                                                          20023410
      THETA= -THETA                                                     20023420
C-----PIVOTS ON 2,3,  2 DRIVES JOUT TO  ZERO , 3 MOVES JOUT TO BOUND    20023430
C                                                                       20023440
 200  RETURN                                                            20023450
      END                                                               20023460
```

```
      SUBROUTINE SETBND(I)                                              20023470
      COMMON /I/ M,L,MPL,MC,NT,ICOST,IC,IPHASE,JRHS,IPT                 20023480
      COMMON /NAMES/ NAME(100)                                          20023490
      K=3                                                               20023500
  100 CONTINUE                                                          20023510
      IF(I) 1,2,3                                                       20023520
    1 J=-I                                                              20023530
      IF(J.LE.NT) NAME(J)=10*(NAME(J)/10)+1                             20023540
    2 RETURN                                                            20023550
    3 IF(I.LE.NT) NAME(I)=10*(NAME(I)/10)+K                             20023560
      RETURN                                                            20023570
C                                                                       20023580
      ENTRY SETBNB                                                      20023590
      K=2                                                               20023600
      GOTO 100                                                          20023610
C                                                                       20023620
      ENTRY SETNNN                                                      20023630
      K=0                                                               20023640
      GOTO 100                                                          20023650
C                                                                       20023660
      ENTRY SETKEY                                                      20023670
      K=4                                                               20023680
      GOTO 100                                                          20023690
      END                                                               20023700
```

```
      SUBROUTINE SETUP                                                  20023710
C------GUB VERSION APRIL/71                                            20023720
      INTEGER  PKT,PKT1                                                 20023730
      COMMON /INPUT/INPUT,INPUTM,INPUTN                                 20023740
      COMMON /LIMS/ MAXTRY,NTRY,JNCORE,NCRMAX,NSCAN                     20023750
      COMMON /I/ M,L,MPL,MC,NT,ICOST,IC,IPHASE,JRHS,IPI                 20023760
      COMMON /A/ ALPHA(101) /B/ BETA(101) /C/ GAMMA(101) /D/ DELTA(101) 20023770
      COMMON /POWTYP/ IROWTP(101) /NAMES/ NAME(100)                     20023780
      COMMON /BASIS/ IBASIS(101),KEYS(101)                              20023790
      COMMON /CORE/ JAREJ(101),JA(101),JAK(101),AJ(1000)                20023800
      COMMON /PARAMS/ TMAX,ITNINV,INVF,K1,K2,K3,K4,NWAJ                 20023810
      COMMON /RHS/ RHS(100)                                             20023820
      COMMON /TOLS/ DJTOL,ZERO,PIVTOL,CTOL,PERTOL,DERTOL                20023830
      COMMON /STATE/ JPOS,IROW,JCOL,JOUT,ITRN,NREJ,NPIF,NDJS            20023840
      COMMON /BOUNDS/ BOUNDS(100),IBDS(100),NBDS                        20023850
      COMMON / CV2 / T(100,10),B0(100),BLO(10),UBS(10),CO(10)           20023860
      COMMON /CV3/ MRBCAV,NBBCAV,NCHGS                                  20023870
C-----TAKES  INPUT A MATRIX IN COLUMNS OFF INPUT FILE BY COLUMNS        20023880
C-----INITIAL SETUP FOR COMPLETE PROBLEM IS CHANGED AT END TO REDUCED PR20023890
C-----OUT DROPS GUB ROWS AS FOUND                                       20023900
      CALL MESSG(40HSETUP                                  )            20023910
C-----ACTUAL PROBLEM SIZES                                              20023920
      M= INPUTM+1                                                       20023930
C-----TRY TO START IN PHASE 2                                           20023940
      IPHASE=2                                                          20023950
      IC=ICOST                                                          20023960
C-----TOLERANCES                                                        20023970
      DJTOL=1.E-8                                                       20023980
      ZERO=1.E-12                                                       20023990
      PIVTOL=1.E-5                                                      20024000
      CTOL=1.E-4                                                        20024010
      PERTOL=1.E-5                                                      20024020
      DERTOL=1.E-8                                                      20024030
      NSCAN=NTRY=MAXTRY=NDJS=ITRN=JNCORE=0                              20024040
C-----INVERT FREQUENCY INVF, ITERATION OF NEXT INVERT ITNINV            20024050
      INVF=100                                                          20024060
      ITNINV=0                                                          20024070
C                                                                       20024080
C                                                                       20024090
C-----FIRST M COLUMNS GIVE ROW LOGICALS AND TYPES                       20024100
      DO 5 I=1,M                                                        20024110
      KEYS(I)=0                                                         20024120
 5    IBASIS(I)=0                                                       20024130
C-----MARK PHASE1 COST ROW FREE FOR POSSIBLE USE IN PHASE 1             20024140
      IROWTP(M)=3                                                       20024150
C-----SET UP LOGICAL VECTORS FOR THE ROWS                               20024160
      DO  10 I=1,M                                                      20024170
 10   ALPHA(I)=0.0                                                      20024180
C-----NOW COUNT COLS WRITTEN                                            20024190
      NT=0                                                              20024200
      DO 100 I=1,M                                                      20024210
      ID=IROWTP(I)                                                      20024220
      IF(ID.EQ.0)  GOTO 20                                              20024230
      IF(ID.EQ.1)  GOTO 21                                              20024240
      IF(ID.EQ.2)  GOTO 22                                              20024250
      IF(ID.EQ.3)  GOTO 23                                              20024260
      IF(ID.EQ.4) GOTO 24                                               20024270
```

```
 18   CALL ERROR(40H  SETUP--ROW TYPE ERROR--OUT OF RANGE          )  20024280
      CALL ESCAPE                                                     20024290
C-----EQUALITY ROW- NO LOGICAL COL.                                   20024300
 20   GOTO 130                                                        20024310
C-----LE. ROW- POSITIVE LOGICAL+SLACK                                 20024320
 21   ALPHA(I)=1.0                                                    20024330
      K=1                                                             20024340
      GOTO 50                                                         20024350
C-----GE. ROW- NEGATIVE LOGICAL+SLACK                                 20024360
 22   ALPHA(I)=-1                                                     20024370
      K=1                                                             20024380
      GOTO 50                                                         20024390
C-----FREE ROW-POSITIVE LOGICAL-BASIC                                 20024400
 23   ALPHA(I)=+1.                                                    20024410
      IBASIS(I)=NT+1                                                  20024420
      K=2                                                             20024430
      GOTO 50                                                         20024440
C-----SUR ROW-NO LOGICAL                                              20024450
 24   CONTINUE                                                        20024460
      GOTO 100                                                        20024470
C-----PLACE COLUMN IN FILE I41 AND I42                                20024480
   50 NT=NT+1                                                         20024490
      NAME(NT)=K                                                      20024500
      CALL OUT(NT,ALPHA,COLNM)                                        20024510
      ALPHA(I)=0                                                      20024520
 100  CONTINUE                                                        20024530
C-----KEEP PHASE 1 COST ROW ZERO IN PHASE 2                           20024540
      IROWTP(M)=0                                                     20024550
C-----NO. OF LOGICAL COLS MC                                          20024560
      MC=NT                                                           20024570
C                                                                     20024580
C-----CYCLE INPUT FILE COLUMS                                         20024590
      REWIND INPUT                                                    20024600
      DO 200 JNT=1,INPUTN                                             20024610
 110  IF(JNT.NE.JPHS)   GOTO 130                                      20024620
      READ (INPUT)  (PHS(J),J=1,INPUTM)                               20024630
C-----TAKE RHS FROM B0 AND SKIP TAPE VERSION                          20024640
      DO 120 J=1,INPUTM                                               20024650
 120  PHS(J)=B0(J)                                                    20024660
      PHS(M)=0.                                                       20024670
      NT=NT+1                                                         20024680
      NAME(NT)=0                                                      20024690
      CALL OUT(NT,PHS,COLNM)                                          20024700
      GOTO 200                                                        20024710
C-----GET NEXT COLUMN JNT                                             20024720
 130  CONTINUE                                                        20024730
      READ(INPUT)(ALPHA(J),J=1,INPUTM)                                20024740
C-----INSERT COLUMN CHANGES TO PROBLEM                                20024750
      IF(JNT.GT.NCHGS)  GOTO 135                                      20024760
      ALPHA(ICOST)=C0(JNT)                                            20024770
 135  CONTINUE                                                        20024780
C-----CHECK FOR COL PACKET, GET PKT NO. OR 0                          20024790
      PKT=0                                                           20024800
      PKT1=0                                                          20024810
      DO 140 I=1,INPUTM                                               20024820
      IF( IROWTP(I).NE.4)  GOTO 14                                    20024830
      PKT1=1+PKT1                                                     20024840
      IF( ALPHA (I).NE.1.) GOTO 140                                   20024850
```

```
      PKT =PKT1                                                          20024860
      GOTO 145                                                           20024870
  140 CONTINUE                                                           20024880
C-----CHECK FOR BOUND, GET BOUND NO. OR 0                                20024890
  145 IF(NBDS.EQ.0) GOTO 151                                             20024900
      DO 150 J=1,NBDS                                                    20024910
      IF ( IBDS(J).EQ.JNT) GOTO 155                                      20024920
  150 CONTINUE                                                           20024930
  151 J=0                                                                20024940
  155 CONTINUE                                                           20024950
C-----SET NAME TO BOUND+PACKET + STATE  AND MARK KEY COLUMN              20024960
      K=1                                                                20024970
C-----COUNT COLUMN AND WRITE TO FILE LESS GUB ELEMENTS                   20024980
  160 NT=1+NT                                                            20024990
      NAME(NT)=K+10*PKT+100000*J                                         20025000
      CALL OUT(NT, ALPHA,COLNM)                                          20025010
  200 CONTINUE                                                           20025020
C-----REMOVE GUB ROWS FROM  IBASIS AND RHS                               20025030
      INON=0                                                             20025040
      L=0                                                                20025050
      IKOST=ICOST                                                        20025060
      DO 220 I=1,M                                                       20025070
      IF(IROWTP(I).EQ.4) GOTO 210                                        20025080
C-----NON-GUB ROE                                                        20025090
      INON=INON+1                                                        20025100
      IBASIS(INON)=100*IBASIS(I)+IROWTP(I)                               20025110
      RHS(INON)=RHS(I)                                                   20025120
      GOTO 220                                                           20025130
C-----GUB POW, STORE RHS IN AJ                                           20025140
  210 L=L+1                                                              20025150
      AJ(L)=RHS(I)                                                       20025160
C-----MOVE DOWN USER COST POW                                            20025170
      IF(I.LT.ICOST) IKOST=IKOST-1                                       20025180
  220 CONTINUE                                                           20025190
C-----NOW REPLACE RHS ON END OF RHS                                      20025200
      IF(L.EQ.0) GOTO 240                                                20025210
      DO 230 I=1,L                                                       20025220
  230 RHS(INON+I)=AJ(I)                                                  20025230
C-----NOW DROP COUNT OF GUB ROWS                                         20025240
      M=M-L                                                              20025250
      ICOST=IKOST                                                        20025260
C-----REDUCED PROBLEM NOW COMPLETE                                       20025270
  240 CONTINUE                                                           20025280
      RETURN                                                             20025290
      END                                                                20025300
```

```
      SUBROUTINE STATUS(NOTE)                                           20025310
      DIMENSION NOTE(4)                                                 20025320
      COMMON /LIMS/ MAXTRY,NTRY,JNCORE,NCRMAX,NSCAN                     20025330
      COMMON /T/ M,L,MPL,MC,NT,ICOST,IC,IPHASE,JPHS,IPI                 20025340
      COMMON /NAMES/ NAME(100)                                          20025350
      COMMON /CORE/ JACEJ(101),JA(101),JAK(101),AJ(100)                 20025360
      COMMON /A/ ALPHA(101) /B/ BETA(101) /C/ GAMMA(101) /D/ DELTA(101) 20025370
      COMMON /BASIS/ IBASIS(101),KEYS(101)                              20025380
      COMMON /DJS/ DJ(101)                                              20025390
      COMMON /STATE/ JPOS,IROW,JCOL,JOUT,ITRN,NREJ,NPIF,NDJS            20025400
      COMMON /PARAMS/ TMAX,ITNINV,TNVF,K1,K2,K3,K4,K5                   20025410
      DATA JNTO/0/                                                      20025420
      LOGICAL BASIC,ATBND                                               20025430
      IF(MOD(K3,11).NE.0) RETURN                                        20025440
      IF( MOD(ITRN  ,50).EQ.0) WRITE(6,1)                               20025450
 1    FORMAT(1H1                                                        20025460
     +           ,10H     PHASE                                        20025470
     +           ,10H      TYPE                                        20025480
     +           ,10H       TRY                                        20025490
     +           ,15H  VAL OBJECTIVE                                   20025500
     +           ,10H      NDJS                                        20025510
     +           ,10H     NAPTS                                        20025520
     +           ,15H    VALUE DJ IN                                   20025530
     +           ,10H    COL IN                                        20025540
     +           ,10H      CODE                                        20025550
     +           ,10H   COL OUT                                        20025560
     +           ,10H      CODE                                        20025570
     +           ,10H     NSCAN          )                            20025580
C-----STORE CURRENT SOLUTION, QUIT OR CONTINUE                         20025590
      CALL SECOND(X)                                                    20025600
      IF(X.LT.TMAX.AND.ITRN.LT.K5) GOTO 999                             20025610
      CALL MAPOUT(8)                                                    20025620
      CALL EXIT                                                         20025630
 999    CONTINUE                                                       20025640
C-----COUNT ACTIVE ARTIFICIALS FOR STATUS DATA                         20025650
      NPIF=0                                                            20025660
      DO 15 I=1,M                                                       20025670
 15   IF(IBASIS(I)/100.GT.NT) NPIF=1+NPIF                               20025680
      COST=-BETA(IC)                                                    20025690
      NCOLS=JNCORE                                                      20025700
      IF(NTRY.NE.0) GOTO 2                                              20025710
      CALL INPOS(JNT)                                                   20025720
      NCOLS=JNT-JNTO                                                    20025730
      IF(NCOLS.LE.0) NCOLS=NCOLS+NT                                     20025740
 20   JNTO=JNT                                                          20025750
      JNSCAN=1000*NSCAN+NCOLS                                           20025760
      MNTRY=1000*MAXTRY+NTRY                                            20025770
      IF(JCOL.EQ.0) GOTO 1                                              20025780
      IF(IROW.EQ.0) GOTO 1                                              20025790
      NJOUT=NAME(JOUT)                                                  20025800
      IF(JOUT.EQ.0) NJOUT=0                                             20025810
      IF(JOUT.GT.NT) NJOUT=1000000+IROW                                 20025820
      WRITE(6,2) IPHASE,ITRN,MNTRY,COST,NDJS,NPIF,DJ(JCOL)             20025830
     +   ,JPOS,NAME(JPOS),JOUT,NJOUT,JNSCAN                             20025840
 2    FORMAT(1H ,3I10,F15.6,2I10,F15.6,5I10)                            20025850
      RETURN                                                            20025860
C-----WHEN NO COLUMN WAS SELECTED                                       20025870
```

```
C-----OR UNBOUNDED                                                    20025880
 10    WRITE(6,3) IPHASE,ITRN,MNTRY,COST,NDJS,NPIF,NOTE,JNSCAN        20025890
 3     FORMAT(1H ,3I10,F15.6,2I10,15H---------------,4A10,I10)        20025900
       RETURN                                                         20025910
C                                                                     20025920
C                                                                     20025930
       ENTRY ERROR                                                    20025940
       WRITE(6,4) NOTE,NOTE,NOTE                                      20025950
 4     FORMAT(1H /(1H+,4A10))                                         20025960
       RETURN                                                         20025970
C                                                                     20025980
C                                                                     20025990
       ENTRY MESSG                                                    20026000
       ENTRY MSSG                                                     20026010
       IF(MOD(K3,7).NE.0) RETURN                                      20026020
       CALL SECOND(X)                                                 20026030
       WRITE(6,5) NOTE,X                                              20026040
 5     FORMAT((1H ,4A10,60X,F10.0,*  SECONDS* )                       20026050
       RETURN                                                         20026060
       END                                                            20026070
```

```
      SUBROUTINE XCHECK(CALLER,AT,B)                                    20026080
      REAL B(1)                                                         20026090
C-----GIVES QUICK CROSS CHECKS AND LOCATION                             20026100
      COMMON /RHS/ RHS(100)                                             20026110
      COMMON  /MOVES/ THETA,BNDJ,DMAX,PRMLER,DUALER                     20026120
      COMMON /PARAMS/ TMAX,ITNINV,INVF,K1,K2,K3,K4,K5                   20026130
      COMMON /A/ ALPHA(101) /B/ BETA(101) /C/ GAMMA(101) /D/ DELTA(101) 20026140
      COMMON /BASIS/ IBASIS(101),KEYS(101)                              20026150
      COMMON /CORE/ JAPEJ(101),JA(101),JAK(1.1),AJ(1000)                20026160
      COMMON /I/ M,L,MPL,MC,NT,ICOST,IC,IPHASE,JRHS,IPT                 20026170
      COMMON /LIMS/ MAXTRY,NTRY,JNCORE,NCRMAX,NSCAN                     20026180
      COMMON /DJS/ DJ(100)                                              20026190
      COMMON /NAMES/ NAME(100)                                          20026200
      COMMON /TOLS/ DJTOL,ZERO,PIVTOL,CTOL,REPTOL,DERTOL                20026210
      COMMON /STATE/ JPOS,IROW,JCOL,JOUT,ITRN,NREJ,NPIF,NDJS            20026220
      COMMON /BOUNDS/ BOUNDS(100),IBDS(100),NBDS                        20026230
      INTEGER DELTA                                                     20026240
      IROWTP(I)=MOD(IBASIS(I),100)                                      20026250
C-----K4 IS 1000*START + STOP ITERATION FOR XCHECKS                     20026260
      IF(K4/1000 .GT.ITRN .OR. MOD(K4,1000).LT.ITRN) RETURN             20026270
      K4=1000*(ITRN+K2)+MOD(K4,1000)                                    20026280
      WRITE(6,1) CALLER,IROW,THETA,BNDJ,JPOS                            20026290
 1    FORMAT(*0.....*/                                                  20026300
     +       * XCHECK CALLED BY *A6*  PIVOT ROW---*I3,                  20026310
     +       *  STEP*E12.5*  BOUND*E11.4*  COLUMN*I5)                   20026320
       WRITE(6,5) (DJ(J),J=1,JNCORE)                                    20026330
6      FORMAT(32X,10F10.4)                                               20026340
      JKOL=JCOL                                                         20026350
      J1=MAXO(JKOL-5,1)                                                 20026360
      J2=MINO(J1+9,JNCORE)                                              20026370
      WRITE(6,5)  (JA(K),K=J1,J2)                                       20026380
 5    FORMAT(32X,10I10)                                                 20026390
      IORG=1                                                            20026400
      JEND=JNCORE*M                                                     20026410
      DO 40 I=1,M                                                       20026420
      JORG=J1*M-M+1                                                     20026430
      DO 30 J=J1,J2                                                     20026440
      AJ(JEND+J)=DOT(M,B(IORG),AJ(JORG) )                               20026450
      IF( ABS(AJ(JEND+J)).LE.ZERO ) AJ(JEND+J)=0.                       20026460
 30   JORG=JORG+M                                                       20026470
      WRITE(6,8) I,IBASIS(I),ALPHA(I),BETA(I),(AJ(JEND+J),J=J1,J2)      20026480
 40   IORG=IORG+M                                                       20026490
      DO 45 J=J1,J2                                                     20026500
      JAJ=JA(J)                                                         20026510
 45   DELTA(J)=NAME(JAJ)                                                20026520
      WRITE(6,5)(DELTA(J),J=J1,J2)                                      20026530
      IF(L.EQ.J) GOTO 60                                                20026540
      DO 50 I=1,L                                                       20026550
      WRITE(6,8) I,KEYS(I),ALPHA(I+M),BETA(I+M)                         20026560
 50   CONTINUE                                                          20026570
 60   CONTINUE                                                          20026580
 8    FORMAT(I3,I7,2E10.2,2X,10E10.2)                                   20026590
C-----ERROR CHECKING OPTION IN XCHECK                                   20026600
 70   CONTINUE                                                          20026610
      IF(MOD(K3,17).NE.0) GOTO 555                                      20026620
C------GAMMA SUMS LHS-RHS                                              20026630
      DO 90 I=1,MPL                                                     20026640
```

```
 90   GAMMA(I)=-RHS(I)                                                  20026650
C-----CYCLE ALL BOOK KEEPING TO GET COLUMNS IN ORDER                   20026660
      LAST=1                                                           20026670
      NVARS=MPL+NBDS                                                   20026680
      DO 500 NVAR=1,NVARS                                              20026690
      NEXT=999999999                                                   20026700
C-----BASIC COLUMNS                                                    20026710
      DO 200 I=1,M                                                     20026720
      J=IBASIS(I)/100                                                  20026730
C-----MARK STRUCTURALS                                                 20026740
      ITAG=2                                                           20026750
      IF(J.LE.NT) GOTO 150                                             20026760
C-----MARK ARTIFICIALS                                                 20026770
      ITAG=5                                                           20026780
      IF(J.LE.NT+100) GOTO 150                                         20026790
C-----MARK NEGATIVE STRUCTURALS                                        20026800
      ITAG=6                                                           20026810
      J=J-(NT+100)                                                     20026820
      IF(J.LE.NT) GOTO 150                                             20026830
C-----MARK NEGATIVE ARTIFICIALS                                        20026840
      ITAG=7                                                           20026850
 150  CONTINUE                                                         20026860
      IF(J.LT.LAST) GOTO 200                                           20026870
      IF(J.GT.NEXT) GOTO 200                                           20026880
      NEXT=J                                                           20026890
      JTYPE=2                                                          20026900
      JTAG=ITAG                                                        20026910
      X=BETA(I)                                                        20026920
      IBAS=I                                                           20026930
 200  CONTINUE                                                         20026940
C-----BOUNDED COLUMNS                                                  20026950
      IF(NBDS.EQ.0) GOTO 300                                           20026960
      NEXTJ=MIN0(NT,NEXT)                                              20026970
      DO 250 J=LAST,NEXTJ                                              20026980
      IF(MOD(NAME(J),10).EQ.3) GOTO 290                                20026990
 250  CONTINUE                                                         20027000
      GOTO 300                                                         20027010
 290  NEXT=J                                                           20027020
      JTYPE=3                                                          20027030
      X=BOUND(J)                                                       20027040
C-----KEY COLUMNS                                                      20027050
 300  CONTINUE                                                         20027060
      IF(L.EQ.0) GOTO 360                                              20027070
      DO 350 I=1,L                                                     20027080
      J=KEYS(I)/100                                                    20027090
      IF(J.LT.LAST) GOTO 350                                           20027100
      IF(J.GT.NEXT) GOTO 350                                           20027110
      NEXT=J                                                           20027120
      JTYPE=4                                                          20027130
      X=BETA(M+I)                                                      20027140
 350  CONTINUE                                                         20027150
 360  CONTINUE                                                         20027160
C                                                                      20027170
C-----GET NEXT COLUMN TO CORE IF REAL (JTAG=2 OR 6)                    20027180
      IF(NEXT.EQ.999999999) GOTO 510                                   20027190
      IF(NEXT.GT.NT) GOTO 400                                          20027200
      CALL IN(NEXT,AJ(JFND+1),JNCORE+1)                                20027210
C-----ADD SUB ELEMENTS                                                 20027220
```

```
      MP1=M+1                                                          20027230
      IF(L.EQ.0) GOTO  385                                             20027240
      DO 380 I=MP1,MPL                                                 20027250
  380 AJ(JEND+I)=0.                                                    20027260
      IGUB=MOD(NAME(NEXT),100000)/10                                   20027270
      IF(IGUB.NE.0) AJ(JEND+M+IGUB)=1.                                 20027280
  385 IF(JTYPE.NE.2) GOTO 450                                          20027290
      IF(JTAG.NE.5) GOTO 450                                           20027300
C-----NEGATIVE STRUCTURALS                                             20027310
      DO 390 I=1,MPL                                                   20027320
  390 AJ(JEND+I)=-AJ(JEND+I)                                           20027330
      AJ(JEND+M)=1.                                                    20027340
      GOTO 450                                                         20027350
C-----ARTIFICIAL VECTOR (JTAG=5 OR 7)                                  20027360
  400 DO 410 I=1,MPL                                                   20027370
  410 AJ(JEND+I)=0.                                                    20027380
      AJ(JEND+IBAS)=1.                                                 20027390
      AJ(JEND+M)=1.                                                    20027400
      IF(JTAG.EQ.7) AJ(JEND+IBAS)=-1.                                  20027410
C                                                                      20027420
C-----SUM X*AJ TO GAMMA-- THE ERROR                                    20027430
  450 DO 460 I=1,MPL                                                   20027440
  460 GAMMA(I)=GAMMA(I)+X*AJ(JEND+I)                                   20027450
  500 LAST=NEXT+1                                                      20027460
  501 FORMAT(4I4,E12.4,10F10.4/(28X,10F10.4))                          20027470
  510 CONTINUE                                                         20027480
C                                                                      20027490
C-----CHECK ERROR AGAINST TOLERANCE                                    20027500
      PRMLER=0.                                                        20027510
      K=0                                                              20027520
      DO 550 I=1,MPL                                                   20027530
      ABSGAM=ABS(GAMMA(I))                                             20027540
      IF(ABSGAM.LE.PERTOL) GOTO 550                                    20027550
      K=K+1                                                            20027560
      DELTA(K)=I                                                       20027570
      GAMMA(K)=GAMMA(I)                                                20027580
      IF(ABSGAM.LE.PRMLER) GOTO 550                                    20027590
      PRMLER=ABSGAM                                                    20027600
  550 CONTINUE                                                         20027610
      IF(PRMLER.LE.PERTOL) WRITE(6,552)                                20027620
      IF(PRMLER.LE.PERTOL) GOTO 555                                    20027630
      WRITE(6,551) PRMLER,PERTOL,(DELTA(I),GAMMA(I),I=1,K)             20027640
      IF(MOD(K3,19).NE.0) GOTO 555                                     20027650
      ITNINV=ITRN                                                      20027660
  551 FORMAT(*0PRIMAL ERRORS EXCEED TOLERANCE---*/                     20027670
     +       * ERROR--*E12.4*   TOLERANCE--*E12.4/(4(I10,E20.8)))      20027680
  552 FORMAT(* ERRORS WITHIN TOLERANCE*)                               20027690
  555 WRITE(6,7)                                                       20027700
    7 FORMAT(1H ,40H---------------------------------------- //  )      20027710
      RETURN                                                           20027720
      END                                                              20027730
```

```
      PROGRAM REPGEN(INPUT,OUTPUT,TAPEA,TAPE5=INPUT,                    30000010
     1 TAPE6=OUTPUT,TAPE9=TAPEA)                                        30000020
      COMMON /VECSTG/ VNAME(10),C,LENP,VLIFE(10),INH(10,16),            30000030
     *  VCOST(10,5),NAMEN(10),COSTS(30,3)                              30000040
      COMMON /BASICS/ CHAP(5000,4),CODE(20),PER(10),IYR(10),LYR(10)     30000050
      COMMON /OUTS/ OANDM(20),SALE(20),SAVE(20),EXIST(10,20),           30000060
     *  PURCH(10,20),STOR(10,20),SALV(10,20),PROC(20),PROT(20)          30000070
      COMMON /PARAMS/ PDTOT,INYR,LAST,NV,NP,TOT,TITLE(4),COST           30000080
      DATA CODE / 2H01,2H02,2H03,2H04,2H05,2H06,2H07,2H08,2H09,2H10,    30000090
     *            2H11,2H12,2H13,2H14,2H15,2H16,2H17,2H18,2H19,2H20/    30000100
      CALL SETUP                                                        30000110
   50 READ(9,100)(TITLE(I),I=1,4)                                       30000120
  100 FORMAT(4A10)                                                      30000130
      IF(EOF,9)7777,200                                                 30000140
  200 PDTOT=0.0                                                         30000150
      DO 300 I=1,20                                                     30000160
      SALE(I)=0.0                                                       30000170
      SAVE(I)=0.0                                                       30000180
      PROC(I)=PROT(I)                                                   30000190
      OANDM(I)=0.0                                                      30000200
      DO 250 N=1,10                                                     30000210
      PURCH(N,I)=0.0                                                    30000220
      EXIST(N,I)=0.0                                                    30000230
      STOR(N,I)=0.0                                                     30000240
      SALV(N,I)=0.0                                                     30000250
  250 CONTINUE                                                          30000260
  300 CONTINUE                                                          30000270
      CALL INSOLN                                                       30000280
      CALL CINFO                                                        30000290
      CALL PINFO                                                        30000300
      GO TO 50                                                          30000310
 7777 STOP                                                              30000320
      END                                                               30000330
```

```
      SUBROUTINE CINFO                                                  30000340
      COMMON /VECSTG/ VNAME(10),C,LENP,VLIFE(10),INH(10,16),            30000350
     *  VCOST(10,5),NAMEN(10),COSTS(30,3)                              30000360
      COMMON /BASICS/ CHAR(5000,4),CODE(2),PER(10),IYR(10),LYR(10)      30000370
      COMMON /OUTS/ OANDM(20),SALE(20),SAVE(20),EXIST(10,20),           30000380
     *  PURCH(10,20),STOR(10,20),SALV(10,20),PROC(20),PROT(20)         30000390
      COMMON /PARAMS/ POTOT,INYR,LAST,NV,NP,TOT,TITLE(4),COST           30000400
      DATA  ONE,TOTAL,PERIOD / 2H01,6HTOTAL ,6HPERIOD /                 30000410
      WRITE(6,100)(TITLE(I),I=1,4)                                      30000420
      SUMT=0.0                                                          30000430
      TPROC=0.0                                                         30000440
      TCOST=0.0                                                         30000450
      DO 500 I=1,20                                                     30000460
  500 TCOST=TCOST+OANDM(I)+SAVE(I)-SALE(I)                              30000470
      TCOST=COST-TCOST-POTOT                                            30000480
      DO 600 I=1,NP                                                     30000490
  600 TPROC=TPROC+PROC(I)                                               30000500
      TPROC=TPROC/TCOST                                                 30000510
      DO 1000 I=1,NP                                                    30000520
      IF(PER(I).EQ.ONE)  N=I                                            30000530
 1000 CONTINUE                                                          30000540
      DO 2000 I=N,NP                                                    30000550
      K1=IYR(I)-INYR+1                                                  30000560
      K2=LYR(I)-INYR+1                                                  30000570
      DO 1500 K=K1,K2                                                   30000580
      IF(K.EQ.K1) GO TO 1500                                            30000590
      OANDM(K1)=OANDM(K1)+OANDM(K)                                      30000600
      SALE(K1)=SALE(K1)+SALE(K)                                         30000610
 1500 CONTINUE                                                          30000620
      J=I-N+1                                                           30000630
      PROC(I)=PROC(I)/TPROC                                             30000640
      OANDM(K1)=OANDM(K1)+SAVE(I)                                       30000650
      SUM=PROC(I)+OANDM(K1)-SALE(K1)                                    30000660
      WRITE(6,200) PERIOD,CODE(J),PROC(I),OANDM(K1),SALE(K1),SUM        30000670
      IF (J.EQ.1) GO TO 2000                                            30000680
      OANDM(1)=OANDM(1)+OANDM(K1)                                       30000690
      SALE(1)=SALE(1)+SALE(K1)                                          30000700
      PROC(N)=PROC(N)+PROC(I)                                           30000710
 2000 SUMT=SUMT+SUM                                                     30000720
      I=LYR(NP)-INYR+2                                                  30000730
      WRITE(6,300) TOTAL,POTOT,PROC(N),OANDM(1),SALE(1),SUMT            30000740
      WRITE(6,400) SALE(I)                                              30000750
  100 FORMAT(1H1,15X,4A10 / 1H-,*COST INFORMATION* /                    30000760
     *1H-,12X,5(1H*,12X) / 13X,1H*,*   R AND D  *, 1H*,                30000770
     ** PROCUREMENT*,1H*,*  OPERATING *,1H*,*   SALVAGE  *,1H*,        30000780
     **     TOTAL    * / 1H ,77(1H*) / 13X,5(1H*,12X))                 30000790
  200 FORMAT(1H ,A6,2X,A2,2X,1H*,12X,4(1H*,1X,F9.3,2X) / 13X,5(1H*,12X))30000800
  300 FORMAT(13X,5(1H*,12X) / 1H ,A6,6X,5(1H*,1X,F9.3,2X) / 1H ,77(1H*))30000810
  400 FORMAT(1H- / 1H-,*TRUNCATION VALUE FOR RESOURCES = *,F9.3)        30000820
      RETURN                                                            30000830
      END                                                               30000840
```

```
      SUBROUTINE INSOLN                                                 30000850
      COMMON /VECSTG/ VNAME(10),C,LENP,VLIFE(10),INH(10,16),            30000860
     *  VCOST(10,5),NAMEN(10),COSTS(30,3)                              30000870
      COMMON /BASICS/ CHAR(5000,4),CODE(20),PER(10),IYR(10),LYR(10)     30000880
      COMMON /OUTS/ DANDM(20),SALE(20),SAVE(20),EXIST(10,20),           30000890
     *  PURCH(10,20),STOR(10,20),SALV(10,20),PROC(20),PROT(20)         30000900
      COMMON /PARAMS/ PDTOT,INYR,LAST,NV,NP,TOI,TITLE(4),COST           30000910
      INTEGER TOT                                                       30000920
      TOT=NP+1                                                          30000930
      DATA X/1HX/,W/1HW/,S/1HS/,BLANK/1H /,BLAN2/2H  /                  30000940
 7777 READ(9,100)IND,VAL                                                30000950
      IF(IND.GE.0) GO TO 101                                            30000960
      COST=VAL                                                          30000970
      GO TO 700                                                         30000980
  101 IF(IND.EQ.0) GO TO 7777                                           30000990
      IF(CHAR(IND,1).EQ.X) GO TO 500                                    30001000
      IF(CHAR(IND,1).EQ.W) GO TO 400                                    30001010
      IF(CHAR(IND,1).EQ.S) GO TO 300                                    30001020
      IF(CHAR(IND,3).NE.BLAN2) GO TO 7777                               30001030
C  INTERPRET PNN VARIABLES FOR INVESTMENT CONSTRAINTS                   30001040
      DO 200 I=1,20                                                     30001050
      IF (PER(I).EQ.CHAR(IND,2)) GO TO 210                              30001060
  200 CONTINUE                                                          30001070
      GO TO 1000                                                        30001080
  210 PROC(I)=PROC(I)-VAL                                               30001090
      PROC(I+1)=PROC(I+1)+VAL                                           30001100
      GO TO 7777                                                        30001110
C  INTERPRET INHERITED FLEET AND PURCHASE FLEET VARIABLES               30001120
  400 DO 405 J=1,20                                                     30001130
      IF(CODE(J).EQ.CHAR(IND,2)) GO TO 410                              30001140
  405 CONTINUE                                                          30001150
      GO TO 1000                                                        30001160
  410 DO 420 I=1,10                                                     30001170
      IF(PER(I).EQ.CHAR(IND,3)) GO TO 430                               30001180
  420 CONTINUE                                                          30001190
      GO TO 1000                                                        30001200
  430 ISTART=IYR(I)                                                     30001210
      IF(CHAR(IND,1).EQ.X) PURCH(J,I)=VAL                               30001220
      DO 450 I=1,10                                                     30001230
      IF(PER(I).EQ.CHAR(IND,4)) GO TO 460                               30001240
  450 CONTINUE                                                          30001250
      GO TO 1000                                                        30001260
  460 IEND=LYR(I)                                                       30001270
      CALL VALUES(J,ISTART,IEND,VAL)                                    30001280
      GO TO 7777                                                        30001290
C  INTERPRET MOTHBALL VARIABLES                                         30001300
  300 DO 350 I=1,20                                                     30001310
      IF(CODE(I).EQ.CHAR(IND,2)) GO TO 360                              30001320
  350 CONTINUE                                                          30001330
      GO TO 1000                                                        30001340
  360 DO 370 J=1,10                                                     30001350
      IF(PER(J).EQ.CHAR(IND,3)) GO TO 380                               30001360
  370 CONTINUE                                                          30001370
      GO TO 1000                                                        30001380
  380 STOR(I,J)=VAL                                                     30001390
      LENP=LYR(J)-IYR(J)+1                                              30001400
      CALL MOTH(I)                                                      30001410
```

```
      SAVE(J)=SAVE(J)+C*VAL                                          30001420
      GO TO 7777                                                     30001430
C  INTERPRET MASTER VARIABLES                                        30001440
  500 IF(CHAR(IND,3).NE.BLAN2) GO TO 4 0                             30001450
      DO 550 I=1,20                                                  30001460
      IF(CODE(I).EQ.CHAR(IND,2)) GO TO 560                           30001470
  550 CONTINUE                                                       30001480
      GO TO 1000                                                     30001490
  560 PURCH(I,TOT)=VAL                                               30001500
      IF(VAL.GT.0.0)                                                 30001510
     *PDTOT=PDTOT+VCOST(I,3)                                         30001520
      GO TO 7777                                                     30001530
C  ERROR MESSAGE                                                     30001540
 1000 WRITE(6,600) (CHAR(IND,I),I=1,4)                               30001550
      STOP                                                           30001560
  700 RETURN                                                         30001570
  100 FORMAT(I4,4X,F12.4)                                            30001580
  600 FORMAT(1H-,*ERROR IN INTERPRETATION OF *,A1,3A2)               30001590
      END                                                            30001600
```

```
      SUBROUTINE PINFO                                                  30001610
      COMMON /VECSTG/ VNAME(10),C,LENP,VLIFE(10),INH(10,16),            30001620
     *  VCOST(10,5),NAMEN(10),COSTS(30,3)                              30001630
      COMMON /BASICS/ CHAR(5000,4),CODE(20),PER(10),IYR(10),LYR(10)     30001640
      COMMON /OUTS/ OANDM(20),SALE(20),SAVE(20),EXIST(10,20),           30001650
     *  PURCH(10,20),STOR(10,20),SALV(10,20),PROC(20),PROT(20)         30001660
      COMMON /PARAMS/ ROTOT,INYR,LAST,NV,NP,TOT,TITLE(4),COST           30001670
      INTEGER TOT                                                       30001680
      DATA TOTAL,PERIOD,BLANK / 6HTOTAL ,6HPERIOD,2H   /                30001690
      WRITE(6,1000)(TITLE(I),I=1,4)                                     30001700
      M=1                                                               30001710
    5 GO TO (10,20,30,40,50,60,70,80,90),NV                             30001720
   10 WRITE(6,1010)(VNAME(I),I=1,NV)                                    30001730
      GO TO 100                                                         30001740
   20 WRITE(6,1020)(VNAME(I),I=1,NV)                                    30001750
      GO TO 100                                                         30001760
   30 WRITE(6,1030)(VNAME(I),I=1,NV)                                    30001770
      GO TO 100                                                         30001780
   40 WRITE(6,1040)(VNAME(I),I=1,NV)                                    30001790
      GO TO 100                                                         30001800
   50 WRITE(6,1050)(VNAME(I),I=1,NV)                                    30001810
      GO TO 100                                                         30001820
   60 WRITE(6,1060)(VNAME(I),I=1,NV)                                    30001830
      GO TO 100                                                         30001840
   70 WRITE(6,1070)(VNAME(I),I=1,NV)                                    30001850
      GO TO 100                                                         30001860
   80 WRITE(6,1080)(VNAME(I),I=1,NV)                                    30001870
      GO TO 100                                                         30001880
   90 WRITE(6,1090)(VNAME(I),I=1,NV)                                    30001890
 1000 FORMAT(1H1,15X,4A10 / 1H-,*PURCHASED RESOURCES*)                  30001900
 1010 FORMAT(1H-,12X,  1H*,12X  /13X,  1H*,2X,A8,2X /1H ,25(1H*)/       30001910
     * 13X,  1H*,12X)                                                  30001920
 1020 FORMAT(1H-,12X,2(1H*,12X) /13X,2(1H*,2X,A8,2X)/1H ,38(1H*)/       30001930
     * 13X,2(1H*,12X) )                                                30001940
 1030 FORMAT(1H-,12X,3(1H*,12X) /13X,3(1H*,2X,A8,2X)/14 ,51(1H*)/       30001950
     * 13X,3(1H*,12X) )                                                30001960
 1040 FORMAT(1H-,12X,4(1H*,12X) /13X,4(1H*,2X,A8,2X)/1H ,64(1H*)/       30001970
     * 13X,4(1H*,12X) )                                                30001980
 1050 FORMAT(1H-,12X,5(1H*,12X) /13X,5(1H*,2X,A8,2X)/1H ,77(1H*)/       30001990
     * 13X,5(1H*,12X) )                                                30002000
 1060 FORMAT(1H-,12X,6(1H*,12X) /13X,6(1H*,2X,A8,2X)/1H ,90(1H*)/       30002010
     * 13X,6(1H*,12X) )                                                30002020
 1070 FORMAT(1H-,12X,7(1H*,12X) /13X,7(1H*,2X,A8,2X)/1H ,103(1H*)/      30002030
     * 13X,7(1H*,12X) )                                                30002040
 1080 FORMAT(1H-,12X,8(1H*,12X) /13X,8(1H*,2X,A8,2X)/1H ,116(1H*)/      30002050
     * 13X,8(1H*,12X) )                                                30002060
 1090 FORMAT(1H-,12X,9(1H*,12X) /13X,9(1H*,2X,A8,2X)/1H ,129(1H*)/      30002070
     * 13X,9(1H*,12X) )                                                30002080
  100 IF(M.GE.2) GO TO 305                                              30002090
      K=0                                                               30002100
      DO 200 I=1,TOT                                                    30002110
      IF(PER(I).EQ.CODE(1)) K=1                                         30002120
      IF(K.NE.1) GO TO 200                                              30002130
      TEMP1=PERIOD                                                      30002140
      TEMP2=PER(I)                                                      30002150
      IF(I.NE.TOT) GO TO 105                                            30002160
      TEMP1=TOTAL                                                       30002170
```

```
      TEMP2=BLANK                                                       30002180
  105 GO TO (110,120,130,140,150,160,170,180,190),NV                    30002190
  110 WRITE(6,1110) TEMP1,TEMP2,(PURCH(J,I),J=1,NV)                     30002200
      GO TO 200                                                         30002210
  120 WRITE(6,1120) TEMP1,TEMP2,(PURCH(J,I),J=1,NV)                     30002220
      GO TO 200                                                         30002230
  130 WRITE(6,1130) TEMP1,TEMP2,(PURCH(J,I),J=1,NV)                     30002240
      GO TO 200                                                         30002250
  140 WRITE(6,1140) TEMP1,TEMP2,(PURCH(J,I),J=1,NV)                     30002260
      GO TO 200                                                         30002270
  150 WRITE(6,1150) TEMP1,TEMP2,(PURCH(J,I),J=1,NV)                     30002280
      GO TO 200                                                         30002290
  160 WRITE(6,1160) TEMP1,TEMP2,(PURCH(J,I),J=1,NV)                     30002300
      GO TO 200                                                         30002310
  170 WRITE(6,1170) TEMP1,TEMP2,(PURCH(J,I),J=1,NV)                     30002320
      GO TO 200                                                         30002330
  180 WRITE(6,1180) TEMP1,TEMP2,(PURCH(J,I),J=1,NV)                     30002340
      GO TO 200                                                         30002350
  190 WRITE(6,1190) TEMP1,TEMP2,(PURCH(J,I),J=1,NV)                     30002360
  200 CONTINUE                                                          30002370
 1110 FORMAT(1H ,A6,2X,A2,2X,  1H*,2X,F8.3,2X  / 13X,  1H*,12X  )       30002380
 1120 FORMAT(1H ,A6,2X,A2,2X,2(1H*,2X,F8.3,2X) / 13X,2(1H*,12X) )       30002390
 1130 FORMAT(1H ,A6,2X,A2,2X,3(1H*,2X,F8.3,2X) / 13X,3(1H*,12X) )       30002400
 1140 FORMAT(1H ,A6,2X,A2,2X,4(1H*,2X,F8.3,2X) / 13X,4(1H*,12X) )       30002410
 1150 FORMAT(1H ,A6,2X,A2,2X,5(1H*,2X,F8.3,2X) / 13X,5(1H*,12X) )       30002420
 1160 FORMAT(1H ,A6,2X,A2,2X,6(1H*,2X,F8.3,2X) / 13X,6(1H*,12X) )       30002430
 1170 FORMAT(1H ,A6,2X,A2,2X,7(1H*,2X,F8.3,2X) / 13X,7(1H*,12X) )       30002440
 1180 FORMAT(1H ,A6,2X,A2,2X,8(1H*,2X,F8.3,2X) / 13X,8(1H*,12X) )       30002450
 1190 FORMAT(1H ,A6,2X,A2,2X,9(1H*,2X,F8.3,2X) / 13X,9(1H*,12X) )       30002460
C                                                                       30002470
C FIRST PART OF THIS SUBROUTINE OUTPUT INFORMATION CONCERNING           30002480
C EQUIPMENT PURCHASES DURING EACH PERIOD .....                          30002490
C NEXT SECTION OUTPUTS RESOURCES STORED                                 30002500
C                                                                       30002510
      WRITE(6,3000) (TITLE(I),I=1,4)                                    30002520
      M=3                                                               30002530
      GO TO 5                                                           30002540
  305 IF(M.EQ.2) GO TO 205                                              30002550
      N=0                                                               30002560
      DO 400 I=1,NP                                                     30002570
      K=IYP(I)-INYP+1                                                   30002580
      IF(K.LE.0) GO TO 400                                              30002590
      N=N+1                                                             30002600
      GO TO (310,320,330,340,350,360,370,380,390),NV                    30002610
  310 WRITE(6,1110)PERIOD,CODE(N),(STOP(J,I),J=1,NV)                    30002620
      GO TO 400                                                         30002630
  320 WRITE(6,1120)PERIOD,CODE(N),(STOP(J,I),J=1,NV)                    30002640
      GO TO 400                                                         30002650
  330 WRITE(6,1130)PERIOD,CODE(N),(STOP(J,I),J=1,NV)                    30002660
      GO TO 400                                                         30002670
  340 WRITE(6,1140)PERIOD,CODE(N),(STOP(J,I),J=1,NV)                    30002680
      GO TO 400                                                         30002690
  350 WRITE(6,1150)PERIOD,CODE(N),(STOP(J,I),J=1,NV)                    30002700
      GO TO 400                                                         30002710
  360 WRITE(6,1160)PERIOD,CODE(N),(STOP(J,I),J=1,NV)                    30002720
      GO TO 400                                                         30002730
  370 WRITE(6,1170)PERIOD,CODE(N),(STOP(J,I),J=1,NV)                    30002740
      GO TO 400                                                         30002750
```

```
  380 WRITE(6,1180)PERIOD,CODE(N),(STOR(J,I),J=1,NV)                    30002760
      GO TO 400                                                         30002770
  390 WRITE(6,1190)PERIOD,CODE(N),(STOR(J,I),J=1,NV)                    30002780
  400 CONTINUE                                                          30002790
 3000 FORMAT(1H1,15X,4A10 / 1H-,*STORED RESOURCES* )                    30002800
C                                                                       30002810
C REMAINING PART WILL OUTPUT THE TOTAL AMOUNT USED                      30002820
C DURING EACH PERIOD                                                    30002830
C                                                                       30002840
      WRITE(6,2000)(TITLE(I),I=1,4)                                     30002850
      M=2                                                               30002860
      GO TO 5                                                           30002870
  205 N=0                                                               30002880
      DO 300 I=1,NP                                                     30002890
      K=IYR(I) -INYR+1                                                  30002900
      IF(K.LE.0) GO TO 300                                              30002910
      DO 206 J=1,NV                                                     30002920
  206 EXIST(J,K)=EXIST(J,K)-STOR(J,I)                                   30002930
      N=N+1                                                             30002940
      GO TO (210,220,230,240,250,260,270,280,290),NV                    30002950
  210 WRITE(6,1110) PERIOD,CODE(N),(EXIST(J,K),J=1,NV)                  30002960
      GO TO 300                                                         30002970
  220 WRITE(6,1120) PERIOD,CODE(N),(EXIST(J,K),J=1,NV)                  30002980
      GO TO 300                                                         30002990
  230 WRITE(6,1130) PERIOD,CODE(N),(EXIST(J,K),J=1,NV)                  30003000
      GO TO 300                                                         30003010
  240 WRITE(6,1140) PERIOD,CODE(N),(EXIST(J,K),J=1,NV)                  30003020
      GO TO 300                                                         30003030
  250 WRITE(6,1150) PERIOD,CODE(N),(EXIST(J,K),J=1,NV)                  30003040
      GO TO 300                                                         30003050
  260 WRITE(6,1160) PERIOD,CODE(N),(EXIST(J,K),J=1,NV)                  30003060
      GO TO 300                                                         30003070
  270 WRITE(6,1170) PERIOD,CODE(N),(EXIST(J,K),J=1,NV)                  30003080
      GO TO 300                                                         30003090
  280 WRITE(6,1180) PERIOD,CODE(N),(EXIST(J,K),J=1,NV)                  30003100
      GO TO 300                                                         30003110
  290 WRITE(6,1190) PERIOD,CODE(N),(EXIST(J,K),J=1,NV)                  30003120
  300 CONTINUE                                                          30003130
      RETURN                                                            30003140
 2000 FORMAT(1H1,15X,4A10 / 1H-,*TOTAL RESOURCES USED* )                30003150
      END                                                               30003160
```

```
      SUBROUTINE SETUP                                                  30003170
      COMMON /VECSTG/ VNAME(10),C,LENP,VLIFE(10),INH(10,16),            30003180
     *  VCOST(10,5),NAMEN(10),COSTS(30,3)                              30003190
      COMMON /BASICS/ CHAR(5000,4),CODE(20),PER(10),IYR(10),LYR(10)     30003200
      COMMON /OUTS/ DANDM(20),SALE(20),SAVE(20),EXIST(10,20),           30003210
     *  BUPCH(10,20),STOR(10,20),SALV(10,20),PROC(20),PROT(20)         30003220
      COMMON /PARAMS/ PDTOT,INYR,LAST,NV,NP,TOT,TITLE(4),COST           30003230
      DIMENSION TEMP(4)                                                 30003240
      DATA IVT,IPT,IED/8HVEHICLE  ,8HPERIOD   ,8HENDTABLE /             30003250
      NVR=0                                                             30003260
      NPT=0                                                             30003270
      READ(5,1000)FNAME,INYR,LAST,NV,NT,NP                              30003280
 1000 FORMAT(A8,2X,6I5)                                                 30003290
   10 READ(5,1000)ITABLE                                                30003300
      IF(ITABLE.EQ.IVT) GO TO 20                                        30003310
      IF(ITABLE.EQ.IPT) GO TO 60                                        30003320
      IF(ITABLE.EQ.IED) GO TO 100                                       30003330
      WRITE(6,2000)ITABLE                                               30003340
 2000 FORMAT(1H-,A8,* IS NOT RECOGNIZED BY SETUP*)                      30003350
      STOP                                                              30003360
   20 NVR=NVR+1                                                         30003370
      READ(5,4000)VNAME(NVR),VLIFE(NVR)                                 30003380
      READ(5,1070)(VCOST(NVR,I),I=1,5)                                  30003390
 1070 FORMAT(5F10.2)                                                    30003400
      GO TO 10                                                          30003410
   60 NPT=NPT+1                                                         30003420
      READ(5,1140) IYR(NPT),LYR(NPT),PER(NPT),PROT(NPT)                 30003430
 1140 FORMAT(I4,I5,1X,A2,F8.2)                                          30003440
      GO TO 10                                                          30003450
 4000 FORMAT(A8,11X,I2)                                                 30003460
  100  CONTINUE                                                         30003470
       PROT(NPT+1) = 0.                                                 30003480
  110  CONTINUE                                                         30003490
      READ(9,3000) I,(TEMP(J),J=1,4)                                    30003500
 3000 FORMAT(I5,4X,A1,3A2)                                              30003510
      IF(EOF,9)200,150                                                  30003520
  150 DO 160 J=1,4                                                      30003530
  160 CHAR(I,J)=TEMP(J)                                                 30003540
       GO TO 110                                                        30003550
  200 RETURN                                                            30003560
      END                                                               30003570
```


ITRN - iteration count

```
      SUBROUTINE VALUES(N,ISTART,IEND,VAL)                              30003580
      COMMON /VECSTG/ VNAME(10),C,LENP,VLIFE(10),INH(10,16),            30003590
     *  VCOST(10,5),NAMEN(10),COSTS(30,3)                               30003600
      COMMON /BASICS/ CHAR(5000,4),CODE(20),PER(10),IYR(10),LYR(10)     30003610
      COMMON /OUTS/ OANDM(20),SALE(20),SAVE(20),EXIST(10,20),           30003620
     *  PURCH(10,20),STOR(10,20),SALV(10,20),PROC(20),PROT(20)          30003630
      COMMON /PARAMS/ PDTOT,INYR,LAST,NV,NP,TOT,TITLE(4),COST           30003640
      CALL YRCOST(N)                                                    30003650
      I=ISTART-INYR                                                     30003660
      II=IEND-ISTART+1                                                  30003670
      K=1                                                               30003680
      DO 10 J=1,II                                                      30003690
      I=I+1                                                             30003700
      IF(I.LE.0) GO TO 10                                               30003710
      OANDM(I)=OANDM(I)+COSTS(J,K)*VAL                                  30003720
      EXIST(N,I)=EXIST(N,I)+VAL                                         30003730
   10 CONTINUE                                                          30003740
      I=I+1                                                             30003750
      K=K+1                                                             30003760
      IF(IEND.EQ.LAST) K=K+1                                            30003770
      SALE(I)=COSTS(J,K)*VAL+SALE(I)                                    30003780
      SALV(N,I)=VAL+SALV(N,I)                                           30003790
      RETURN                                                            30003800
      END                                                               30003810
```

```
      SUBROUTINE YRCOST(J)                                                  10008630
C  A SUBROUTINE TO COMPUTE THE OPERATING, SALVAGE, AND TRUNCATION          10008640
C  COSTS YEAR BY YEAR.  ALSO THE YEARLY MOTHBALLING SAVING IS COMPUTED.    10008650
      COMMON /VECSTG/ VNAME(10), C,LENP, VLIFE(10), TNH(10,16),             10008660
     * VCOST(10,5), NAMEN(10), COSTS(30,3)                                 10008670
      INTEGER VNAME,VLIFE                                                   10008680
C  ASSUME THE OPERATING AND MAINTANCE COST INCREASES AT R*100 PER-CENT     10008690
C  A YEAR (NOT A COMPOUND RATE INCEASE)                                    10008700
      R=0.0                                                                 10008710
C                                                                           10008720
C  LET X= THE 1ST YEAR C. AND M. COST.  THEN                               10008730
C                          X+(1+R)*X+(+2*R)*X+...+(1+9*R)*X=VCOST(J,2)     10008740
      X= VCOST(J,2)/(10.0 + 45.0*R)                                         10008750
C  ASSUME NO PERIOD IS LONGER THAN 6 YEARS.                                10008760
      IB=VLIFE(J) +10                                                       10008770
      DO 10 I=1,IB                                                          10008780
      COSTS(I,1)=(1.0 + FLOAT(I-1)*R)*X*(VCOST(J,4)**(I-1))                 10008790
   10 CONTINUE                                                              10008800
C                                                                           10008810
C  ASSUME THE SALVAGE VALUE OF A VEHICLE AFTER I YEARS OF SERVICE IS       10008820
C  (ALPHA)**I *PURCHASE COST.                                              10008830
      ALPHA=0.5
      Y=VCOST(J,1)                                                          10008850
      DO 20 I=1,IB                                                          10008860
      Y= ALPHA*Y                                                            10008870
      COSTS(I,2)=Y                                                          10008880
   20 CONTINUE                                                              10008890
C                                                                           10008900
C        ASSUME TRUNCATION AFTER IYEARS OF SERVICE IS                       10008910
C              (VLIFE-I)*(PURCHASE COST)/VLIFE                              10008920
C                                                                           10008930
      Y=VCOST(J,1)/VLIFE(J)                                                 10008940
      DO 30 I=1,IB                                                          10008950
      IX=VLIFE(J)-I                                                         10008960
      IF (IX.LT.0) IX=0                                                     10008970
      COSTS(I,3)=IX*Y                                                       10008980
   30 CONTINUE                                                              10008990
      RETURN                                                                10009000
      ENTRY MOTH                                                            10009010
C  ASSSUME THE MOTHBALLING SAVING IS P1*100 PER CENT OF THE FIRST YEAR COST-X
      P1=0.90
C     C=0
C     DO 546 IL=1,LENP
C 546 C=C-0.1*P1*VCOST(J,2)*VCOST(J,4)**(IL-1)
C     C =-X * P1
      C=-VCOST(J,2)/(10.0 + 45.0*R) * P1
      RETURN                                                                10009080
      END                                                                   10009090
```

APPENDIX E

ERROR MESSAGES

ERROR MESSAGES FROM MATRIX GENERATOR

". . . is not a table name."

This message indicates that the input deck is not properly constructed since the program has read a card which should have been a header card but was not. The location of the error can be narrowed down by checking the output listing to see which tables have been correctly read. This error terminates execution.

"Vehicle name . . . not defined in a vehicle."

This message is output when a task table is being read. It indicates either that the vehicle name is misspelled or located improperly on the card, or that the task table has preceded the vehicle table, if the vehicle table exists. This error also terminates execution.

"The period tables are out of order."

This message indicates that the first year of the period just read was not equal to one plus the last year of the last period read. This can be caused by improper sequencing or improper definition of the periods. This error will cause execution to terminate.

"Warning--the number of tables input was not the expected number."

This message does not terminate execution, but does indicate that there was a difference between the number of tables indicated on the title card and the number actually read by the program.

"Incorrectly read file . . . columns read as . . ."
"The M-1 column was . . ., unable to find RHS mark."
"Reached EOF while writing column . . . and row . . ."

These three error messages all refer to errors encountered when trying to convert the MPS360 file to the file for BBCAV2. If one of

these errors occurs, a major problem exists within the program. As a result these prevent the creation of the BBCAV2 file, but allow the program to execute to completion to give the analyst the most information possible about the problem.

ERROR MESSAGES FROM MAIN PROGRAM

"BLIST size exceeded"

BLIST is the array used for storing nodes of the branching tree. It is presently dimensioned to handle 25 nodes. When there exist more than 25 nodes which have been defined but have not been evaluated, this message is generated. It indicates that this particular problem is converging very slowly, and if one desires an accurate answer then the arrays EKBL, PSIGL, NXBL, XNXBL, and BLIST should be enlarged. This error causes the system to print out the best solution found and proceed to the next problem.

"Time is up . . . cycling to next problem."
"Have solved max. no. of LP probs."

These two messages inform one that the solution which is output is not necessarily optimal but was caused by one of the input parameters. The first message indicates a violation of the time indicated by the second field of the real parameter card. The second message is a result of reaching the limit on the number of nodes (LP problems) which is set in the last field of the integer parameter card.

"Premature EOF on a matrix tape at column . . ."

This message indicates that the size of the tape file does not correspond with the size indicated on the integer parameter card. It also gives an indication of the size of the tape file for comparison against that which was input. This error terminates execution of the program.

"IO--column not located in NT reads"
"Row--key not in core"
"Insert cannot find rejected column"
"PIVOT--PIVOT less than PIVTOL"
"KEYCH--essential packet no basic column"

These five error messages are used exclusively for debugging, and should not occur in normal operation. The general cause for this is that some section of core has been overwritten accidently.

"PIVOT dropped column . . ."

This message indicates that a column was removed from the basis during the inversion process. This occurs when the input basis is not feasible, and when numerical errors have caused the current basis to "drift" out of the feasible region.

ERROR MESSAGES FROM REPORT GENERATOR

". . . is not recognized by SETUP."

The routine SETUP has encountered an error in the input deck while attempting to read a table name. This error terminates execution.

"Error in interpretation of . . ."

The program has been unable to determine the meaning of the seven-character code indicated in the message. If the code is a valid one (one of the forms shown in Fig. 11), then there is probably an error in the period descriptions of the input deck. There is also possibility of other errors in the input deck or, as a last resort, of errors in the reference list file. If the code is not a valid one, then the error must be in the reference list. This error also terminates execution.

GLOSSARY

This section contains the mnemonic definitions for all three programs—GENLCP, BBCAV2, and REPGEN. It is arranged into two major sections. The first section lists the mnemonics in labeled common—then the local variables contained within each subroutine, for each of the three programs, respectively. The second section is an overall alphabetical listing for handy reference. Note that in this listing, the same mnemonic may have two or more meanings. Each entry is identified here as a local or global variable, and is cross-referenced to the first section. Use of the two sections, in conjunction, should eliminate any ambiguity.

Section I

GENLCP CODING DEFINITIONS

COMMON/VECSTG/

VNAME (10)	- vehicle names
C	- temporary storage for cost data
LENP	- length of period
VLIFE (10)	- maximum life of resource (vehicle)
INH (10, 16)	- number of each type resource inherited from each year
VCOST (10,5)	- cost data for each resource
NAMEN (10)	- pointers for numbering resources
COST (30, 3)	- yearly operating, salvage and truncation costs

COMMON/ALTSTG/

ALTER (288,9)	- array used for eliminating infeasible alternatives from tasks
YAVL (10)	- year resource first available

COMMON/TSKSTG/

U (7, 288, 9)	- array of task alternatives
NTSK (9)	- number of alternatives in task

COMMON/PRDSTG/

NPERYR (10, 3)	- first and last year of period and number of tasks in period
NPTASK (10, 9)	- ID number of each task in period
PTASK (10, 9)	- multiplicative factor for all values in associated task for each period

LOCAL VARIABLES

GENLCP

ALPHA	- temporary storage for attrition
AU (16)	- temporary storage for alternatives

BUDG (10) - limit on procurement expenditures in each period

CMAX - temporary cost storage for ordered resources

FNAME - file name

IHVN (10) - pointers for inherited vehicles

INHYRS - number of years from which vehicles are inherited

ITABLE - temporary storage for table name

LIFER - temporary storage for remaining useful life of a vehicle

LY - last year of problem

MAXL - temporary storage for vehicle life

MCOL - number of columns in matrix

NAMES (10) - temporary pointers

NINHP - number of inherited periods

NIV - number of inherited vehicle types

NL (10), NN (10) - temporary storage used in formatting output

NPP - number of periods

NPT - number of period tables read

NRD - number of vehicles having R&D

NROW - number of rows in matrix

NT - number of tasks

NTR - number of task tables read

NV - number of vehicle types

NVEHU (10) - indicates if vehicle used in period

NVR - number of vehicle tables read

NYR - temporary storage for last year of period

ONE - "1.0"

ONEM - "-1.0"

SY - start year of problem

UB (10) - calculated upper bounds on resources

UMAX - temporary storage for greatest quantity of a specific vehicle which might be used in a task

YEARS (21) - stores inherited years

YRINT (20) - scale factor for all tasks in period

YRCOST

ALPHA - rate of decrease in salvage value

R - rate of increase in operating cost

R1 - portion of operating cost refunded for mothballing resource

YINTERP

JSUB (10) - pointers for vehicle subscripts

VMIN - temporary storage for minimum quantity of vehicles which can be used for a task

MATFILL

C - "COLUMNS"

CNAME - column name for which RVAL is being derived

CTEMP - temporary storage for column name

IROWTP (100) - indicates row type; all set to zero except generalized upper bound rows which are set to 4

ITEMP - temporary storage for first letter of RNAME

R - "RHS"

RNAME (120) - row names

RTEMP - temporary storage for row names

RVAL (100) - vector of values in each row for a specific column

VAL - temporary storage for value of specific row and column

BBCAV2 CODING DEFINITIONS

COMMON/CV1/

IP (12)	- storage for input parameters on integer parameter card
RP (12)	- storage for real parameters, first four locations are for input from real parameter card, rest are temporary storage
TMP (10)	- temporary storage

COMMON/CV2/

T (100, 10)	- storage for columns of matrix associated with nonlinear variables
BO (100)	- right-hand-side vector
BLO (10)	- set of lower bounds on nonlinear variables
ULO (10)	- set of upper bounds on nonlinear variables
CO (10)	- vector for linear approximation for nonlinear cost functions

COMMON/CV3/

M	- number of rows in matrix
N	- number of columns in matrix
NCF	- number of nonlinear variables
PHIT	- cost of a nonlinear solution
UZ	- cost of best nonlinear solution
USP	- UZ $(1 + \epsilon)^{-1}$
USM	- UZ $(1 - \epsilon)^{-1}$
EKO	- cost associated with the lower bounds of the node
MPLUS	- number of rows in the matrix including the cost row (M + 1)

COMMON/CV4/

IX (110)	- columns in basic solution
X (110)	- values associated with columns in IX

IXZ (110) - columns in best solution

XZ (110) - values associated with columns in IXZ

XCON (10) - stores values found in X which are associated with the nonlinear variables

COST - cost of the solution returned from the LP

COMMON/CV5/

SIGMA (100, 4) - stores information which defines the current node

TSIG - temporary storage associated with EKO

LSTMAX - maximum length which the branching list has achieved

COMMON/CV7/

NPHASE - stores LP phase code

NF1 - signifies feasible solution when set equal to 1

CFX - no longer used

IOPT - used to flag unbounded solution

NOP - node number

NOPS - nodes solved

NEWXZ - flags when new best solution found and should be output

COMMON/CV8/

NXBK - index of branching variable

XK - value of branching variable

NOBOL - number of nodes on list

EKBL (25) - EKO value associated with each node on the list

COMMON/CV9/

PSIGL (25) - lower bound associated with each node on list

NXBL (25) - index of branching variable for each node

XNXBL (25) - value of branching variable for each node

BLIST (25, 131)- branching list; contains right-hand-side vector, plus upper bounds, lower bounds, and linear cost approximations for nonlinear variables

COMMON/TMX/

TMO	- time SET was called
EXT	- time when time limit on problem will expire

COMMON/CORE/

AJ (5000)	- columns in core plus basis inverse
JA (101)	- in-core column disc indices
JAK (101)	- dummy storage area
JAREJ (101)	- set to 1 when corresponding in-core column rejected

COMMON/PARAMS/

TMAX	- maximum time before MAPOUT
ITNINV	- iteration of next invert
INVF	- invert frequency
K1	- not used
K2	- not used
K3	- output control parameter
K4	- XCHECK control parameter
K5	- maximum LP iterations before MAPOUT

COMMON/INPUT/

INPUT	- file containing input matrix
INPUTM	- number of rows in matrix
INPUTN	- number of columns in matrix

COMMON/FILES/

IA1	- disc file for matrix less GUB rows
IA2	- disc file for packed matrix less GUB rows
IMAP	- file for starting and terminating basis

COMMON/STATE/

IROW	- current selected row

ITRN - iteration count

JCOL - current selected column

JOUT - rejected column index

JPOS - selected column index

NDJS - number of negative DJ's

NPIF - number of primal infeasibilities

NREJ - number of rejected in-core columns

COMMON/LIMS/

JNCORE - number of columns in core

MAXTRY - maximum number of in-core iterations

NCRMAX - maximum number of columns which fit in core

NSCAN - number of disc reads

NTRY - number of in-core iterations

COMMON/IXX/

IX (100) - indices of solution columns

COMMON/XX/

X (100) - values of solution columns

COMMON/TOLS/

CTOL - cost tolerance for infeasibility

DERTOL - dual error tolerance; not used

DJTOL - DJ tolerance

PERTOL - primal error tolerance

PIVTOL - pivot tolerance

ZERO - smallest recognized number

COMMON/BASIS/

IBASIS (101) - basic columns for non-GUB rows

KEYS (101) - storage of GUB key columns

COMMON/DJS/

DJ (100)	- values of current in-core DJ's

COMMON/MOVES/

BNDJ	- value of current column bound
DMAX	- largest DJ value stored
DUALER	- dual error; unused
PRMLER	- primal error; unused
THETA	- step chosen by ROW, adjusted in PRIMAL

COMMON/I/

IC	- current cost row
ICOST	- user's cost row
IPHASE	- current LP phase
IPI	- current location of PI vector in basis
JRHS	- user's input RHS
L	- number of GUB rows
M	- number of active interval rows
MC	- last logical column
MPL	- M plus L
NT	- total number of columns (MC + INPUTN)

COMMON/A/

ALPHA (101)	- work space, usually current column inverse

COMMON/B/

BETA (101)	- work space usually values of basic and key variables

COMMON/C/

GAMMA (101)	- not used

COMMON/D/

DELTA (101)	- not used

COMMON/ROWTYP/

IROWTYP (101) - user's input row types

COMMON/NAMES/

NAME (600) - state of each variable or column

COMMON/BOUNDS/

BOUNDS (100) - values of upper bounds

IBDS (100) - column indices of bound columns

NBDS - number of bounds

COMMON/RHS/

RHS (100) - stores user's current right-hand-side

LOCAL VARIABLES

BBCAV2 and BOX1

BLT (10) - temporary storage for BLO

BBK - lower bound on branching variable

BBK2 - value of branching variable

COST1 - solution cost for lower branch

COST2 - solution cost for upper branch

CT (10) - temporary storage for CO

EPSI - epsilon value from real parameter card

ESIG - temporary storage for EKO

ICOL - temporary storage for column index

INDIC - indicates which branch (upper or lower) is being solved

LSTFRE (25) - gives locations of storage areas on the branching list which are vacant

MNC - the negative of NCF

MNX - the negative of N

NCF1 - NCF

NCF4 - NORA + 3 * NCF

NFREE - number of gaps (empty location between two filled locations) in the BLIST

NMIN - index of the lowest bound on the BLIST, or N-1, depending on where it is used

NOL - index for storage on BLIST

NORA - M

NXB - temporary storage for next branching variable

PH1 and PH2 - temporary storage of values from GETPHI

PMIN - value of lowest bound on BLIST

TSTO (130) - temporary storage

TITLE (4) - alphanumeric title of problem

UBK - upper bound on branching variable

UBK2 - difference between upper bound and value for branching variable

ULT (10) - temporary storage for ULO

US - temporary storage for USP

INITA

AJ (100) - temporary storage for column of matrix

DUM1 and DUM2 - temporary storage for reading unused sections of tape

READIN

NC - number of basis cards to be read from input

TIMEC

SECS - actual CPU clock time

XX - elapsed time on problem

GETASQ

TEMP - location used while swapping contents of two locations in an array

NEM1 - number of elements in an array minus one

GETC

DIF	- difference between upper and lower bound for a variable
FX1 (10)	- cost function values for lower bounds
FX2 (10)	- cost function values for upper bounds
ICX	- number of variables for which cost slopes are to be derived

NXBRN

BLT (10)	- temporary storage for BLO
CT (10)	- temporary storage for CO
YT (10)	- differences between solution point and lower bounds
FX1 (10)	- cost function values for lower bounds
FX2 (10)	- cost function values for solution point
DIF (10)	- differences between cost functions and linear approximations
NDX (10)	- indices of nonlinear variables
NFX	- the negative of NCF
XT (10)	- solution values for nonlinear variables

PRESET AND PARAMS

IBMAX	- maximum number of nodes which may be stored on BLIST
JBMAX	- maximum number of words of information which may be stored for each node in BLIST
NORA	- number of rows in the matrix including the objective function

LP

B (100)	- basis inverse stored by rows
IORG	- origin of basis inverse
MROWS	- user's number of rows
NCHGS	- user's number of bound columns

NCOLS - user's number of columns

NWAJ - storage dimension of the array AJ

SETUP

ID - local row type being processed

IKOST - temporary storage of user's cost row

INON - temporary number of non-GUB rows found

PKT1 - temporary count of GUB row packet columns

PKT - actual GUB row column being processed

IO

ALPHA - column to be written or read

B - address of origin of basis inverse

JCOL - core position of column being read

JNT - index of columns read

KEY - index of key column to be located

KOL1 - last column read on file IA1

KOL2 - last column read on file IA2

KOL - column to be located on either file or packet number of desired key

NAAM - not used

NAME - column name, or position in core to which column is read

PACK (100) - temporary storage of packed column

ZS - parameter used to pack coefficients

Z - parameter used to pack index of coefficient

MAPIN

ATBND - "ATBND"

BASIC - "BASIC"

BNDJ - value of bound

B - origin of basis inverse

CARD (8) - image of map card

ENDER - "END"

ID - column number from map card

INVERSE - "INVERS"

KEE - "KEY"

MM - number of elements in basis inverse

NAMES (5) - column indices from map card

NULL - "NULL"

PKT - storage of column packet

ROWS - "ROWS"

TYPE1 - first word on map card

TYPE2 - second work on map card

MAPOUT

IBAS - count of basis variables

IBND - count of bound variables

IKEY - count of key variables

INLL - count of null variables

JCOL - user's column index of column processed

JNCORE - number of columns in core

MAPBAS (100) - basic column indices

MAPBND (100) - bound column indices

MAPKEY (1000) - key column indices

MAPNLL (10) - null column indices

MM - number of elements in basis inverse

MP1 - M plus 1

INVERT

ATBND - column type

BASIC - column type

BNDJ	- cound on current column
B	- origin of basis inverse
IORG	- origin of first element in B
ITYPE	- row type
JNT	- current column index
JORG	- origin in AJ to which column is read
JTYPE	- variable type
KORG	- origin in AJ to which key column is read
PKTO	- GUB packet number of column in AJ (KORG)
PKT	- GUB packet number of column being processed

FEASCH

BNDJ	- bound on current column
B	- basis inverse
IORG	- origin of any row in B
JPKT	- GUB packet of current column
KEY	- switch to return key processing to key loop
NB	- number of basic variables in a packet
SUMIE	- sum of infeasibilities
SUM	- value of variable before feasibility adjustment

PRIMAL

BASIC	- column type
B	- basis inverse
EPSI	- value of new basic variable
ITYPE	- type of step to be used
JOUTPK	- GUB packet of column rejected
JPOSPK	- GUB packet of column entering
NBVPKT	- number of basis variable in selected GUB row

NPEGLM - maximum rejection due to degeneracy

NDEG - number of degeneracy rejections

NEWROW - row for column changing from key to basic

STATUS

ATBND - state of a column

BASIC - state of a column

B - basis inverse

COST - value of current objective function

JNSCAN - columns in core + 1000 times number of rewinds of file IA1

JNTO - index of last column read from disc

JNT - last column read from disc (if MNTRY = 0)

MNTRY - number of in-core iterations

NCOLS - number of columns read from disc file IA1

NJOUT - name code of column to be rejected

NOTE (4) - 40 character comment

X - elapsed CPU seconds

ROW

BASIC - state of a column

B - basis inverse

IB - basic column index

IORG - origin of basis inverse

IROW - row calling parameter, row of zero

ITYPE - type of step; 1-unbounded, 2-column to zero, 3-column to bound

JCOL - core index of selected column

JORG - core origin of selected column

JOUT - column to be rejected

JPKT - GUB packet of column selected

JPOS - disc index of column selected

KORG - origin of KEY column for packet JPKT

STEP - step to current row

THETA - best feasible step

COLUMN

ATBND - logical column state

BASIC - logical column state

B - basis inverse

JCOL - core position of selected column

JKEY - core position of key for JCOL (if in GUB row)

JORG - origin of a row in B

JPKTO - current stored GUB key packet

JPKT - GUB packet of new column

JTYPE - type of column selected

KORG - origin of KEY in AJ

NCORE - number of columns in core

NDJST - number of negative DJ's from disk read

NULL - column state

PIKEY - PJ value for current KEY JPKT

CHECK

ATBND - state of column

BASIC - state of column

B - basis inverse

DJ - current column sensitivity

JCOUNT - count of columns processed

JFBCH - number of columns, checked in current batch

JNT - index of current column

JORG - origin in AJ to which columns are read

JTYPE - type of column being processed

KORG - origin of key column in AJ

NBCH - number of columns in batch

NFBCH - number of columns retained from batch

PIKEY - DJ for current key at KORG

PKTO - packet of current key

PKT - packet of new column, JNT

INSERT

B - basis inverse

DJ - DJ for column to be stored

DMAX - largest DJ of stored columns

D (15) - DJ's of stored columns

ID (15) - indices of stored columns

JORG - origin of vacancy for column in AJ

JPOSR - disc index of column to be rejected

JPOS - disc index of column to be stored

JREJ - origin of rejected column in AJ

NPBCH - number of columns to be saved from batch

N - number of columns currently saved

KEYCH

B - basis inverse

IB - disc index of basic column for current row

IORG - origin of a row in B

IROW - row to which key column is shifted when made basic

JCOLPK - GUB packet of column being moved from KEY

JCOL - column to be moved

JKEY - candidate key column

JORG - origin of a row in B

MPK - row of column which was KEY

SUM - temporary storage

PIVOT

ALPHA - column to be pivoted into basis

B - basis inverse

DIVOT - candidate pivot while searching for best

IORG - origin of pivot row in B

IROW - pivot row

JORG - origin of a row in B

JP - basic column for a row

PIV - pivot used

SETBND

I - input disk column index

J - absolute value of I

K - new state

DOT

DOT - double precision inner product of X and Y

DOTS - single precision inner product of X and Y

M - vector dimension

SUM - double precision accumulator

X - input vector

Y - input vector

BOUND

BOUND - value of column bound (or 10**70)

IB - bound index in IBDS

J - input disc column index

KEYFIND

I	- dummy variable
JAJ	- potential column's in-core position
JPKT	- GUB packet number for column
JTYPE	- column type
KEYFIND	- position of key found
KEY	- column number of key to be located
PKT	- GUB packet of desired key

ESCAPE

AALPHA	- "ALPHA"
ABASIS	- "BASIS"
ABETA	- "BETA"
ADELTA	- "DELTA"
ADJ	- "DJ"
AGAMMA	- "GAMMA"
AJAREJ	- "JAREJ"
AJA	- "JA"
AKEY	- "KEY"
ANAME	- "NAME "
B	- basis inverse

XCHECK

ATBND	- logical column state
AT	- dummy
BASIC	- logical column state
B	- basis inverse
CALLER	- calling name
IORG	- origin of a row in basis inverse

JAJ	- disk index of an in-core column
JEND	- origin of vacant work space in AJ
JORG	- origin of a column in AJ
J1	- first column in column printout
J2	- last column in column printout

COMMON/VECSTG/

VNAME (10) - stores resource names

C - temporary storage location used in calculating savings from resource storage

LENP - length of period under consideration

VLIFE (10) - expected resource life

INH (10, 16) - not used

VCOST (10, 5) - the five costs associated with each resource are stored in this array; in order, they are salvage and truncation, operating, R&D, retention rate, and procurement. (Explained in detail in matrix generator description.)

NAMEN (10) - not used

COSTS (30, 3) - cost of operating (1), selling (2), or truncating (3), a resource in the 1st thru 30th year of its life

COMMON/BASICS/

CHAR (5000, 4) - storage of column names which have been broken down into their four meaningful parts

CODE (20) - storage of the numbers 1 - 20 in two digit alphanumeric form

PER (10) - pointers for two digit, alphanumeric code for periods

IYR (10) - initial year of each period

LYR (10) - last year of each period

COMMON/OUTS/

OANDM (20) - operating cost for each year

SALE (20) - salvage or truncation value for each year

SAVE (20) - savings from resource storage for each year

EXIST (10, 20) - number of each type resource available in each year

PURCH (10, 20) - number of each type resource purchased in each year

STOR (10, 20) - number of each type resource stored in each year

SALV (10, 20) - number of each type resource disposed of at end of each year

PROC (20) - procurement funds spent during each period

PROT (20) - procurement funds available during each period

COMMON/PARAMS/

RDTOT - total R&D expenditures

INYR - initial year of problem

LAST - last year of problem

NV - number of resource types

NP - number of subperiods

TOT - number of subperiods plus 1

TITLE (4) - name of specific solution

COST - total cost of solution

LOCAL VARIABLES

SETUP

FNAME - problem title (not used)

IED - "ENDTABLE"

IPT - "PERIOD"

ITABLE - table name

IVT - "VEHICLE"

NPT - period tables read in

NT - number of tasks (not used)

NVR - number of resources read in

TEMP (4) - temporary storage for column names

INSOLN

BLANK - " "

IEND - last year of resource existance

IND - column number temporary storage

ISTART - first year of resource existance

S - "S"

VAL - column value temporary storage

W - "W"

X - "X"

CINFD

PERIOD - "PERIOD"

ONE - "01"

SUM - total cost for a period

SUMT - total cost for all periods

TCOST - temporary storage for total procurement

TOTAL - "TOTAL"

TPROC - correction factor for procurement

PINFO

TEMP1 -
} temporary storage locations for alphanumeric output
TEMP2 -

BLANK - " "

PERIOD - "PERIOD"

TOTAL - "TOTAL"

```
AALPHA - 'ALPHA'
                ( LOCAL - MAIN PROGRAM'S ESCAPE )
ABASIS - 'BASIS'
                ( LOCAL - MAIN PROGRAM'S ESCAPE )
ABETA - 'BETA'
                ( LOCAL - MAIN PROGRAM'S ESCAPE )
ADELTA - 'DELTA'
                ( LOCAL - MAIN PROGRAM'S ESCAPE )
ADJ - 'DJ'
                ( LOCAL - MAIN PROGRAM'S ESCAPE )
AGAMMA - 'GAMMA'
                ( LOCAL - MAIN PROGRAM'S ESCAPE )
AJAREJ - 'JAREJ'
                ( LOCAL - MAIN PROGRAM'S ESCAPE )
AJA - 'JA'
                ( LOCAL - MAIN PROGRAM'S ESCAPE )
AJ(5000) - COLUMNS IN CORE PLUS BASIS INVERSE
                (GLOBAL - MAIN PROGRAM'S COMMON / CORE / )
AJ(100) - TEMPORARY STORAGE FOR COLUMN OF MATRIX
                ( LOCAL - MAIN PROGRAM'S INITA )
AKEY - 'KEY'
                ( LOCAL - MAIN PROGRAM'S ESCAPE )
ALPHA(101) - WORK SPACE, USUALLY CURRENT COLUMN INVERSE
                (GLOBAL - MAIN PROGRAM'S COMMON / A / )
ALPHA - COLUMN TO BE WRITTEN OR READ
                ( LOCAL - MAIN PROGRAM'S IO )
ALPHA - TEMP STORAGE FOR ATTRITION
                ( LOCAL - MATRIX GENERATOR'S GENLOP )
ALPHA - RATE OF DECREASE IN SALVAGE VALUE
                ( LOCAL - MATRIX GENERATOR'S YRCOST )
ALPHA - COLUMN TO BE PIVOTED INTO BASIS
                ( LOCAL - MAIN PROGRAM'S PIVOT )
ALTER (288, 9) - ARRAY USED FOR ELIMINATING INFEASIBLE ALTERNATIVES FROM TASK
                (GLOBAL - MATRIX GENERATOR'S COMMON / ALTSTG / )
ANAME - 'NAME'
                ( LOCAL - MAIN PROGRAM'S ESCAPE )
AT - DUMMY
                ( LOCAL - MAIN PROGRAM'S XCHECK )
ATBND - 'ATBND'
                ( LOCAL - MAIN PROGRAM'S MAPIN )
ATBND - COLUMN TYPE
                ( LOCAL - MAIN PROGRAM'S INVERT )
ATBND - LOGICAL COLUMN STATE
                ( LOCAL - MAIN PROGRAM'S XCHECK )
                ( LOCAL - MAIN PROGRAM'S CHECK )
                ( LOCAL - MAIN PROGRAM'S COLUMN )
                ( LOCAL - MAIN PROGRAM'S STATUS )
AU (16) - TEMP. STORAGE FOR ALTERNATIVES
                ( LOCAL - MATRIX GENERATOR'S GENLOP )
```

```
B - BASIS INVERSE
                ( LOCAL - MAIN PROGRAM:S LP )
                ( LOCAL - MAIN PROGRAM:S XCHECK )
                ( LOCAL - MAIN PROGRAM:S ESCAPE )
                ( LOCAL - MAIN PROGRAM:S PIVOT )
                ( LOCAL - MAIN PROGRAM:S KEYCH )
                ( LOCAL - MAIN PROGRAM:S INSERT )
                ( LOCAL - MAIN PROGRAM:S CHECK )
                ( LOCAL - MAIN PROGRAM:S COLUMN )
                ( LOCAL - MAIN PROGRAM:S ROW )
                ( LOCAL - MAIN PROGRAM:S STATUS )
                ( LOCAL - MAIN PROGRAM:S PRIMAL )
                ( LOCAL - MAIN PROGRAM:S FEASCH )
                ( LOCAL - MAIN PROGRAM:S INVERT )
                ( LOCAL - MAIN PROGRAM:S MAPIN )
                ( LOCAL - MAIN PROGRAM:S IO )
BASIC - 'BASIC'
                ( LOCAL - MAIN PROGRAM:S MAPIN )
BASIC - COLUMN TYPE
                ( LOCAL - MAIN PROGRAM:S INVERT )
                ( LOCAL - MAIN PROGRAM:S PRIMAL )
BASIC - LOGICAL COLUMN STATE
                ( LOCAL - MAIN PROGRAM:S XCHECK )
                ( LOCAL - MAIN PROGRAM:S CHECK )
                ( LOCAL - MAIN PROGRAM:S COLUMN )
                ( LOCAL - MAIN PROGRAM:S STATUS )
                ( LOCAL - MAIN PROGRAM:S ROW )
BBK - LOWER BOUND ON BRANCHING VARIABLE
                ( LOCAL - MAIN PROGRAM:S BRCAV2 )
BBK2 - VALUE OF BRANCHING VARIABLE
                ( LOCAL - MAIN PROGRAM:S BRCAV2 )
BETA(101) - WORK SPACE, USUALLY VALUES OF BASIC AND KEY VARIABLES
                (GLOBAL - MAIN PROGRAM:S COMMON / B / )
BLANK - '      '
                ( LOCAL - REPORT GENERATOR:S INSOLN )
                ( LOCAL - REPORT GENERATOR:S RINFO )
BLIST(25,131) - BRANCHING LIST, CONTAINS RIGHT-HAND-SIDE VECTOR, PLUS UPPER
BOUNDS, LOWER BOUNDS AND LINEAR COST APPROXIMATIONS FOR NON-LINEAR VARIABLE
                (GLOBAL - MAIN PROGRAM:S COMMON / CV2 / )
BLO(10) - SET OF LOWER BOUNDS ON NON-LINEAR VARIABLES
                (GLOBAL - MAIN PROGRAM:S COMMON / CV2 / )
BLT(10) - TEMPORARY STORAGE FOR BLO
                ( LOCAL - MAIN PROGRAM:S BRCAV2 )
                ( LOCAL - MAIN PROGRAM:S NXBRN )
BNDJ - BOUND ON CURRENT COLUMN
                (GLOBAL - MAIN PROGRAM:S COMMON / MOVES / )
BOUNDS(100) - VALUES OF UPPER BOUNDS
                (GLOBAL - MAIN PROGRAM:S COMMON / BOUNDS / )
BOUND - VALUE OF COLUMN BOUND (OR 10 ** 20)
                ( LOCAL - MAIN PROGRAM:S BOUND )
BO(100) - RIGHT-HAND-SIDE VECTOR
                (GLOBAL - MAIN PROGRAM:S COMMON / CV2 / )
BUDG (10) - LIMIT ON PROCUREMENT EXPENDITURES IN EACH PERIOD
                ( LOCAL - MATRIX GENERATOR:S GENLCP )
```

```
C - TEMP. STORAGE FOR COST DATA
                (GLOBAL - MATRIX GENERATOR'S COMMON / VECSTG / )
C - TEMPORARY STORAGE LOCATION USED IN CALCULATING SAVINGS FROM RESOURCE
STORAGE
                (GLOBAL - REPORT GENERATOR'S COMMON / VECSTG / )
C - 'COLUMN'
                ( LOCAL - MATRIX GENERATOR'S MATFILL)
CALLER - CALLING NAME
                ( LOCAL - MAIN PROGRAM'S XCHECK )
CARD(8) - IMAGE OF MAP CARD
                ( LOCAL - MAIN PROGRAM'S MAPIN )
CFX - NO LONGER USED
                (GLOBAL - MAIN PROGRAM'S COMMON / CV7 / )
CHAR(5000,4) - STORAGE OF COLUMN NAMES WHICH HAVE BEEN BROKEN DOWN INTO
THEIR FOUR MEANINGFUL PARTS
                (GLOBAL - REPORT GENERATOR'S COMMON / BASICS / )
CMAX - TEMP. COST STORAGE FOR ORDERING RESOURCES
                ( LOCAL - MATRIX GENERATOR'S GENLOD )
CNAME - COLUMN NAME FOR WHICH RVAL IS BEING DERIVED
                ( LOCAL - MATRIX GENERATOR'S MATFILL)
CODE(20) - STORAGE OF THE NUMBERS 1 - 20 IN TWO DIGIT ALPHANUMERIC FORM
                (GLOBAL - REPORT GENERATOR'S COMMON / BASICS / )
COST - VALUE OF CURRENT OBJECTIVE FUNCTION
                ( LOCAL - MAIN PROGRAM'S STATUS )
COST - TOTAL COST OF SOLUTION
                (GLOBAL - REPORT GENERATOR'S COMMON / PARAMS / )
COST - COST OF THE SOLUTION RETURNED FROM THE LP
                (GLOBAL - MAIN PROGRAM'S COMMON / CV4 / )
COST1 - SOLUTION COST FOR LOWER BRANCH
                ( LOCAL - MAIN PROGRAM'S BRCAV2 )
COST2 - SOLUTION COST FOR UPPER BRANCH
                ( LOCAL - MAIN PROGRAM'S BRCAV2 )
COSTS (30,3) - COST OF OPERATING (1), SELLING (2) OR TRUNCATING (3) A
RESOURCE IN THE 1ST THRU 30TH YEAR OF ITS LIFE
                (GLOBAL - MATRIX GENERATOR'S COMMON / VECSTG / )
                (GLOBAL - REPORT GENERATOR'S COMMON / VECSTG / )
CO(10) - VECTOR FOR LINEAR APPROXIMATION FOR NON-LINEAR COST FUNCTIONS
                (GLOBAL - MAIN PROGRAM'S COMMON / CV2 / )
CTEMP - TEMP. STORAGE FOR COLUMN NAME
                ( LOCAL - MATRIX GENERATOR'S MATFILL)
CTOL - COST TOLERANCE FOR INFEASIBILITY
                (GLOBAL - MAIN PROGRAM'S COMMON / TOLS / )
CT(10) - TEMPORARY STORAGE FOR CO
                ( LOCAL - MAIN PROGRAM'S BRCAV2 )
                ( LOCAL - MAIN PROGRAM'S NXBRN )
DELTA(101) - NOT USED
                (GLOBAL - MAIN PROGRAM'S COMMON / D / )
DERTOL - DUAL ERROR TOLERANCE. NOT USED
                (GLOBAL - MAIN PROGRAM'S COMMON / TOLS / )
DIF - DIFFERENCE BETWEEN UPPER AND LOWER BOUND FOR A VARIABLE
                ( LOCAL - MAIN PROGRAM'S GETC )
DIF(10) - DIFFERENCES BETWEEN COST FUNCTIONS AND LINEAR APPROXIMATIONS
                ( LOCAL - MAIN PROGRAM'S NXBRN )
```

```
DIVOT - CANDIDATE PIVOT WHILE SEARCHING FOR BEST
                ( LOCAL - MAIN PROGRAM'S PIVOT )
DJ(100) - VALUES OF CURRENT IN-CORE DJ'S
                (GLOBAL - MAIN PROGRAM'S COMMON / DJS / )
DJ - DJ FOR COLUMN TO BE STORED
                ( LOCAL - MAIN PROGRAM'S INSERT )
DJ - CURRENT COLUMN SENSITIVITY
                ( LOCAL - MAIN PROGRAM'S CHECK )
DJTOL - DJ TOLERANCE
                (GLOBAL - MAIN PROGRAM'S COMMON / TOLS / )
DMAX - LARGEST DJ OF STORED COLUMNS
                (GLOBAL - MAIN PROGRAM'S COMMON / MOVES / )
DOT - DOUBLE PRECISION INNER PRODUCT OF X AND Y
                ( LOCAL - MAIN PROGRAM'S DOT )
DOTS - SINGLE PRECISION INNER PRODUCT OF X AND Y
                ( LOCAL - MAIN PROGRAM'S DOT )
D(15) - DJ'S OF STORED COLUMNS
                ( LOCAL - MAIN PROGRAM'S INSERT )
DUALER - DUAL ERROR, UNUSED
                (GLOBAL - MAIN PROGRAM'S COMMON / MOVES / )
DUM1 AND DUM2 - TEMPORARY STORAGE FOR READING UNUSED SECTIONS OF TAPE
                ( LOCAL - MAIN PROGRAM'S INITA )
EKBL(25) - EKO VALUE ASSOCIATED WITH EACH NODE ON THE LIST
                (GLOBAL - MAIN PROGRAM'S COMMON / CV8 / )
EKO - COST ASSOCIATED WITH THE LOWER BOUNDS OF THE NODE
                (GLOBAL - MAIN PROGRAM'S COMMON / CV3 / )
ENDER - 'END'
                ( LOCAL - MAIN PROGRAM'S MAPIN )
EPSI - EPSILON VALUE FROM REAL PARAMETER CARD
                ( LOCAL - MAIN PROGRAM'S BRCAV2 )
EPSI - VALUE OF NEW BASIC VARIABLE
                ( LOCAL - MAIN PROGRAM'S PRIMAL )
ESIG - TEMPORARY STORAGE FOR EKO
                ( LOCAL - MAIN PROGRAM'S BRCAV2 )
EXIST(10,20) - NUMBER OF EACH TYPE RESOURCE AVAILABLE IN EACH YEAR
                (GLOBAL - REPORT GENERATOR'S COMMON / OUTS / )
EXT - TIME WHEN TIME LIMIT ON PROBLEM WILL EXPIRE
                (GLOBAL - MAIN PROGRAM'S COMMON / TMX / )
FNAME - PROBLEM TITLE (NOT USED)
                ( LOCAL - REPORT GENERATOR'S SETUP )
FNAME - FILE NAME
                ( LOCAL - MATRIX GENERATOR'S GENLCP )
FX1(10) - COST FUNCTION VALUES FOR LOWER BOUNDS
                ( LOCAL - MAIN PROGRAM'S GETC )
                ( LOCAL - MAIN PROGRAM'S NXBRN )
FX2(10) - COST FUNCTION VALUES FOR UPPER BOUND
                ( LOCAL - MAIN PROGRAM'S GETC )
FX2(10) - COST FUNCTION VALUES FOR SOLUTION POINT
                ( LOCAL - MAIN PROGRAM'S NXBRN )
GAMMA(101) - NOT USED
                (GLOBAL - MAIN PROGRAM'S COMMON / C / )
I - DUMMY VARIABLE
                ( LOCAL - MAIN PROGRAM'S KEYEND )
```

```
I - INPUT DISK COLUMN INDEX
                ( LOCAL - MAIN PROGRAM'S SETBND )
IA1 - DISC FILE FOR MATRIX LESS GUB ROWS
                (GLOBAL - MAIN PROGRAM'S COMMON / FILES / )
IA2 - DISC FILE FOR PACKED MATRIX LESS GUB ROWS
                (GLOBAL - MAIN PROGRAM'S COMMON / FILES / )
IB - BASIC COLUMN INDEX
                ( LOCAL - MAIN PROGRAM'S ROW )
IB - DISC INDEX OF BASIC COLUMN FOR CURRENT ROW
                ( LOCAL - MAIN PROGRAM'S KEYCH )
IB - BOUND INDEX IN IBDS
                ( LOCAL - MAIN PROGRAM'S BOUND )
IBAS - COUNT OF BASIS VARIABLES
                ( LOCAL - MAIN PROGRAM'S MAPOUT )
IBASIS(101) - BASIC COLUMNS FOR NON-GUB ROWS
                (GLOBAL - MAIN PROGRAM'S COMMON / BASIS / )
IBDS(100) - COLUMN INDICES OF BOUND COLUMNS
                (GLOBAL - MAIN PROGRAM'S COMMON / BOUNDS / )
IBMAX - MAXIMUM NUMBER OF NODES WHICH MAY BE STORED ON BLIST
                ( LOCAL - MAIN PROGRAM'S PRESET )
IBND - COUNT OF BOUND VARIABLES
                ( LOCAL - MAIN PROGRAM'S MAPOUT )
IC - CURRENT COST ROW
                (GLOBAL - MAIN PROGRAM'S COMMON / I / )
ICOST - USER'S COST ROW
                (GLOBAL - MAIN PROGRAM'S COMMON / I / )
ICOL - TEMPORARY STORAGE FOR COLUMN INDEX
                ( LOCAL - MAIN PROGRAM'S BBCAV2 )
ICX - NUMBER OF VARIABLES FOR WHICH COST SLOPES ARE TO BE DERIVED
                ( LOCAL - MAIN PROGRAM'S GETC )
ID - LOCAL ROW TYPE BEING PROCESSED
                ( LOCAL - MAIN PROGRAM'S SETUP )
ID - COLUMN NUMBER FROM MAP CARD
                ( LOCAL - MAIN PROGRAM'S MAPIN )
ID(15) - INDICES OF STORED COLUMNS
                ( LOCAL - MAIN PROGRAM'S INSERT )
IED - 'ENDTABLE'
                ( LOCAL - REPORT GENERATOR'S SETUP )
IEND - LAST YEAR OF RESOURCE EXISTANCE
                ( LOCAL - REPORT GENERATOR'S INSOLN )
IHVN (10) - POINTERS FOR INHERITED VEHICLES
                ( LOCAL - MATRIX GENERATOR'S GENLCP )
IKEY - COUNT OF KEY VARIABLES
                ( LOCAL - MAIN PROGRAM'S MAPOUT )
IKOST - TEMPORARY STORAGE OF USER'S COST ROW
                ( LOCAL - MAIN PROGRAM'S SETUP )
IMAP - FILE FOR STARTING AND TERMINATING BASIS
                (GLOBAL - MAIN PROGRAM'S COMMON / FILES / )
INDIC - INDICATES WHICH BRANCH (UPPER OR LOWER) IS BEING SOLVED
                ( LOCAL - MAIN PROGRAM'S BBCAV2 )
IND - COLUMN NUMBER TEMPORARY STORAGE
                ( LOCAL - REPORT GENERATOR'S INSOLN )
```

```
INH (10, 16) - NUMBER OF EACH TYPE RESOURCE INHERITED FROM EACH YEAR
               (GLOBAL - MATRIX GENERATOR'S COMMON / VECSTG / )
INH(10,16) - NOT USED
               (GLOBAL - REPORT GENERATOR'S COMMON / VECSTG / )
INHYRS - NUMBER OF YEARS FROM WHICH VEHICLES ARE INHERITED
               ( LOCAL - MATRIX GENERATOR'S GENLOP )
INLL - COUNT OF NULL VARIABLES
               ( LOCAL - MAIN PROGRAM'S MAPOUT )
INON - TEMPORARY NUMBER OF NON GUB ROWS FOUND
               ( LOCAL - MAIN PROGRAM'S SETUP )
INPUT - FILE CONTAINING INPUT MATRIX
               (GLOBAL - MAIN PROGRAM'S COMMON / INPUT / )
INPUTM - NUMBER OF ROWS IN MATRIX
               (GLOBAL - MAIN PROGRAM'S COMMON / INPUT / )
INPUTN - NUMBER OF COLUMNS IN MATRIX
               (GLOBAL - MAIN PROGRAM'S COMMON / INPUT / )
INVF - INVERT FREQUENCY
               (GLOBAL - MAIN PROGRAM'S COMMON / PARAMS / )
INVERS - 'INVERS'
               ( LOCAL - MAIN PROGRAM'S MAPIN )
INYR - INITIAL YEAR OF PROBLEM
               (GLOBAL - REPORT GENERATOR'S COMMON / PARAMS / )
IOPT - USED TO FLAG UNBOUNDED SOLUTION
               (GLOBAL - MAIN PROGRAM'S COMMON / CV7 / )
IORG - ORIGIN OF BASIS INVERSE
               ( LOCAL - MAIN PROGRAM'S LP )
               ( LOCAL - MAIN PROGRAM'S ROW )
               ( LOCAL - MAIN PROGRAM'S INVERT )
IORG - ORIGIN OF PIVOT ROW IN B
               ( LOCAL - MAIN PROGRAM'S PIVOT )
IORG - ORIGIN OF A ROW IN BASIS INVERSE
               ( LOCAL - MAIN PROGRAM'S XCHECK )
               ( LOCAL - MAIN PROGRAM'S KEYCH )
               ( LOCAL - MAIN PROGRAM'S FEASCH )
IPHASE - CURRENT LP PHASE
               (GLOBAL - MAIN PROGRAM'S COMMON / I / )
IPI - CURRENT LOCATION OF PI VECTOR IN BASIS
               (GLOBAL - MAIN PROGRAM'S COMMON / I / )
IPT - 'PERIOD'
               ( LOCAL - REPORT GENERATOR'S SETUP )
IP(12) - STORAGE FOR INPUT PARAMETERS ON INTEGER PARAMETER CARD
               (GLOBAL - MAIN PROGRAM'S COMMON / CV1 / )
IROWTYP(101) - USER'S INPUT ROW TYPES
               (GLOBAL - MAIN PROGRAM'S COMMON / ROWTYP / )
IROWTP(100) - INDICATES ROW TYPE J ALL SET TO ZERO EXCEPT GENERALIZED UPPER
BOUND ROWS WHICH ARE SET TO 4
               ( LOCAL - MATRIX GENERATOR'S MATFILL)
IROW - CURRENT SELECTED ROW
               (GLOBAL - MAIN PROGRAM'S COMMON / STATE / )
IROW - ROW CALLING PARAMETER, ROW OR ZERO
               ( LOCAL - MAIN PROGRAM'S ROW )
IROW - ROW TO WHICH KEY COLUMN IS SHIFTED WHEN MADE BASIC
               ( LOCAL - MAIN PROGRAM'S KEYCH )
IROW - PIVOT ROW
               ( LOCAL - MAIN PROGRAM'S PIVOT )
```

```
ISTART - FIRST YEAR OF RESOURCE EXISTANCE
                ( LOCAL - REPORT GENERATOR'S INSOLN )
ITABLE - TABLE NAME
                ( LOCAL - MATRIX GENERATOR'S GENLOP )
                ( LOCAL - REPORT GENERATOR'S SETUP )
ITEMP - TEMP. STORAGE FOR FIRST LETTER OF RNAME
                ( LOCAL - MATRIX GENERATOR'S MATFILL)
ITNINV - ITERATION OF NEXT INVERT
                (GLOBAL - MAIN PROGRAM'S COMMON / PARAMS / )
ITRN - ITERATION COUNT
                (GLOBAL - MAIN PROGRAM'S COMMON / STATE / )
ITYPE - ROW TYPE
                ( LOCAL - MAIN PROGRAM'S INVERT )
ITYPE - TYPE OF STEP, 1-UNBOUNDED, 2-COLUMN TO ZERO, 3-COLUMN    BOUND
                ( LOCAL - MAIN PROGRAM'S ROW )
                ( LOCAL - MAIN PROGRAM'S PRIMAL )
IVT - 'VEHICLE'
                ( LOCAL - REPORT GENERATOR'S SETUP )
IX(100) - INDICES OF SOLUTION COLUMNS
                (GLOBAL - MAIN PROGRAM'S COMMON / IXX / )
IX(110) - COLUMNS IN BASIC SOLUTION
                (GLOBAL - MAIN PROGRAM'S COMMON / CV4 / )
IXZ(110) - COLUMNS IN BEST SOLUTION
                (GLOBAL - MAIN PROGRAM'S COMMON / CV4 / )
IYR(10) - INITIAL YEAR OF EACH PERIOD
                (GLOBAL - REPORT GENERATOR'S COMMON / BASICS / )
J - ABSOLUTE VALUE OF I
                ( LOCAL - MAIN PROGRAM'S SETBND )
J - INPUT DISC COLUMN INDEX
                ( LOCAL - MAIN PROGRAM'S BOUND )
J1 - FIRST COLUMN IN COLUMN PRINTOUT
                ( LOCAL - MAIN PROGRAM'S XCHECK )
J2 - LAST COLUMN IN COLUMN PRINTOUT
                ( LOCAL - MAIN PROGRAM'S XCHECK )
JAJ - DISK INDEX OF AN IN-CORE COLUMN
                ( LOCAL - MAIN PROGRAM'S XCHECK )
JAJ - POTENTIAL COLUMN'S IN-CORE POSITION
                ( LOCAL - MAIN PROGRAM'S KEYEND )
JAK(101) - DUMMY STORAGE AREA
                (GLOBAL - MAIN PROGRAM'S COMMON / CORE / )
JAREJ(101) - SET TO 1 WHEN CORRESPONDING IN-CORE COLUMN REJECTED
                (GLOBAL - MAIN PROGRAM'S COMMON / CORE / )
JA(101) - IN-CORE COLUMN DISC INDICES
                (GLOBAL - MAIN PROGRAM'S COMMON / CORE / )
JBMAX - MAXIMUM NUMBER OF WORDS OF INFORMATION WHICH MAY BE STORED FOR
EACH NODE IN BLIST
                ( LOCAL - MAIN PROGRAM'S PRESET )
JCOL - CURRENT SELECTED COLUMN
                (GLOBAL - MAIN PROGRAM'S COMMON / STATE / )
JCOL - USER'S COLUMN INDEX OF COLUMN PROCESSED
                ( LOCAL - MAIN PROGRAM'S MAPOUT )
JCOL - CORE POSITION OF SELECTED COLUMN
                ( LOCAL - MAIN PROGRAM'S COLUMN )
                ( LOCAL - MAIN PROGRAM'S IO )
                ( LOCAL - MAIN PROGRAM'S ROW )
```

```
JCOL - COLUMN TO BE MOVED
                ( LOCAL - MAIN PROGRAM:S KEYCH )
JCOLPK - SUB PACKET OF COLUMN BEING MOVED FROM KEY
                ( LOCAL - MAIN PROGRAM:S KEYCH )
JCOUNT - COUNT OF COLUMNS PROCESSED
                ( LOCAL - MAIN PROGRAM:S CHECK )
JEND - ORIGIN OF VACANT WORK SPACE IN AJ
                ( LOCAL - MAIN PROGRAM:S XCHECK )
JERCH - NUMBER OF COLUMNS CHECKED IN CURRENT BATCH
                ( LOCAL - MAIN PROGRAM:S CHECK )
JKEY - CORE POSITION OF KEY FOR JCOL (IF SUB ROW)
                ( LOCAL - MAIN PROGRAM:S COLUMN )
JKEY - CANDIDATE KEY COLUMN
                ( LOCAL - MAIN PROGRAM:S KEYCH )
JNCORE - NUMBER OF COLUMNS IN CORE
                (GLOBAL - MAIN PROGRAM:S COMMON / LIMS / )
                ( LOCAL - MAIN PROGRAM:S MAPOUT )
JNSCAN - COLUMNS IN CORE + 1000* NUMBER OF REWINDS OF FILE IA1
                ( LOCAL - MAIN PROGRAM:S STATUS )
JNT - INDEX OF COLUMNS READ
                ( LOCAL - MAIN PROGRAM:S IO )
JNT - CURRENT COLUMN INDEX
                ( LOCAL - MAIN PROGRAM:S CHECK )
                ( LOCAL - MAIN PROGRAM:S INVERT )
JNT - LAST COLUMN READ FROM DISC (IF MNTRY = 0)
                ( LOCAL - MAIN PROGRAM:S STATUS )
JNTO - INDEX OF LAST COLUMN READ FROM DISC
                ( LOCAL - MAIN PROGRAM:S STATUS )
JORG - CORE ORIGIN OF SELECTED COLUMN
                ( LOCAL - MAIN PROGRAM:S ROW )
JORG - ORIGIN OF VACANCY FOR COLUMN IN AJ
                ( LOCAL - MAIN PROGRAM:S INSERT )
JORG - ORIGIN IN AJ TO WHICH COLUMN IS READ
                ( LOCAL - MAIN PROGRAM:S CHECK )
                ( LOCAL - MAIN PROGRAM:S INVERT )
JORG - ORIGIN OF A ROW IN 9
                ( LOCAL - MAIN PROGRAM:S KEYCH )
                ( LOCAL - MAIN PROGRAM:S COLUMN )
                ( LOCAL - MAIN PROGRAM:S PIVOT )
JORG - ORIGIN OF A COLUMN IN AJ
                ( LOCAL - MAIN PROGRAM:S XCHECK )
JOUT - REJECTED COLUMN INDEX
                (GLOBAL - MAIN PROGRAM:S COMMON / STATE / )
JOUT - COLUMN TO BE REJECTED
                ( LOCAL - MAIN PROGRAM:S ROW )
JOUTPK - SUB PACKET OF COLUMN REJECTED
                ( LOCAL - MAIN PROGRAM:S PRIMAL )
JP - BASIC COLUMN FOR A ROW
                ( LOCAL - MAIN PROGRAM:S PIVOT )
JPKT - SUB PACKET OF NEW COLUMN
                ( LOCAL - MAIN PROGRAM:S COLUMN )
                ( LOCAL - MAIN PROGRAM:S ROW )
```

```
JPKT - GUB PACKET OF CURRENT COLUMN
                ( LOCAL - MAIN PROGRAM'S FEASCH )
                ( LOCAL - MAIN PROGRAM'S KEYFND )
JPKTO - CURRENT STORED GUB KEY PACKET
                ( LOCAL - MAIN PROGRAM'S COLUMN )
JPOS - SELECTED COLUMN INDEX
                (GLOBAL - MAIN PROGRAM'S COMMON / STATE / )
JPOS - DISC INDEX OF COLUMN SELECTED
                ( LOCAL - MAIN PROGRAM'S ROW )
JPOS - DISC INDEX OF COLUMN TO BE STORED
                ( LOCAL - MAIN PROGRAM'S INSERT )
JPOSPK - GUB PACKET OF COLUMN ENTERING
                ( LOCAL - MAIN PROGRAM'S PRIMAL )
JPOSR- DISC INDEX OF COLUMN TO BE REJECTED
                ( LOCAL - MAIN PROGRAM'S INSERT )
JREJ - ORIGIN OF REJECTED COLUMN IN AJ
                ( LOCAL - MAIN PROGRAM'S INSERT )
JRHS - USER'S INPUT RHS
                (GLOBAL - MAIN PROGRAM'S COMMON / I / )
JSUB(10) - POINTERS FOR VEHICLE SUBSCRIPTS
                ( LOCAL - MATRIX GENERATOR'S YINTERP )
JTYPE - VARIABLE TYPE
                ( LOCAL - MAIN PROGRAM'S INVERT )
JTYPE - COLUMN TYPE
                ( LOCAL - MAIN PROGRAM'S KEYFND )
                ( LOCAL - MAIN PROGRAM'S CHECK )
                ( LOCAL - MAIN PROGRAM'S COLUMN )
K - NEW STATE
                ( LOCAL - MAIN PROGRAM'S SETBND )
K1 - NOT USED
                (GLOBAL - MAIN PROGRAM'S COMMON / PARAMS / )
K2 - NOT USED
                (GLOBAL - MAIN PROGRAM'S COMMON / PARAMS / )
K3 - OUTPUT CONTROL PARAMETER
                (GLOBAL - MAIN PROGRAM'S COMMON / PARAMS / )
K4 - XCHECK CONTROL PARAMETER
                (GLOBAL - MAIN PROGRAM'S COMMON / PARAMS / )
K5 - MAXIMUM LP ITERATIONS BEFORE MAPOUT
                (GLOBAL - MAIN PROGRAM'S COMMON / PARAMS / )
KEE - 'KEY'
                ( LOCAL - MAIN PROGRAM'S MAPIN )
KEY - INDEX OF KEY COLUMN TO BE LOCATED
                ( LOCAL - MAIN PROGRAM'S IO )
                ( LOCAL - MAIN PROGRAM'S KEYFND )
KEY - SWITCH TO RETURN KEY PROCESSING TO KEY LOOP
                ( LOCAL - MAIN PROGRAM'S FEASCH )
KEYS(101)-STORAGE OF GUB KEY COLUMNS
                (GLOBAL - MAIN PROGRAM'S COMMON / BASIS / )
KEYFND - POSITION OF KEY FOUND
                ( LOCAL - MAIN PROGRAM'S KEYFND )
KOL - COLUMN TO BE LOCATED ON EITHER FILE, OR PACKET NUMBER OF DESIRED KEY
                ( LOCAL - MAIN PROGRAM'S IO )
KOL1 - LAST COLUMN READ ON FILE 1A1
                ( LOCAL - MAIN PROGRAM'S IO )
```

```
KOL2 - LAST COLUMN READ ON FILE IA2
                ( LOCAL - MAIN PROGRAM'S IO )
KORG - ORIGIN IN AJ TO WHICH KEY COLUMN IS READ
                ( LOCAL - MAIN PROGRAM'S INVERT )
KORG - ORIGIN OF KEY COLUMN FOR PACKET JPKT
                ( LOCAL - MAIN PROGRAM'S POW )
KORG - ORIGIN OF KEY COLUMN IN AJ
                ( LOCAL - MAIN PROGRAM'S CHECK )
                ( LOCAL - MAIN PROGRAM'S COLUMN )
L - NUMBER OF SUB ROWS
                (GLOBAL - MAIN PROGRAM'S COMMON / I / )
LAST - LAST YEAR OF PROBLEM
                (GLOBAL - REPORT GENERATOR'S COMMON / PARAMS / )
LEND - LENGTH OF PERIOD UNDER CONSIDERATION
                (GLOBAL - MATRIX GENERATOR'S COMMON / VECSTG / )
                (GLOBAL - REPORT GENERATOR'S COMMON / VECSTG / )
LIFER - TEMP. STORAGE FOR REMAINING USEFUL LIFE OF A VEHICLE
                ( LOCAL - MATRIX GENERATOR'S GENLCP )
LSTMAX - MAXIMUM LENGTH WHICH THE BRANCHING LIST HAS ACHIEVED
                (GLOBAL - MAIN PROGRAM'S COMMON / CV5 / )
LSTFRE(25) - GIVES LOCATIONS OF STORAGE AREAS ON THE BRANCHING LIST WHICH
ARE VACANT
                ( LOCAL - MAIN PROGRAM'S PRCAV2 )
LY - LAST YEAR OF A PROBLEM
                ( LOCAL - MATRIX GENERATOR'S GENLCP )
LYR(10) - LAST YEAR OF EACH PERIOD
                (GLOBAL - REPORT GENERATOR'S COMMON / BASICS / )
M - NUMBER OF ACTIVE INTERNAL ROWS
                (GLOBAL - MAIN PROGRAM'S COMMON / I / )
M - NUMBER OF ROWS IN MATRIX
                (GLOBAL - MAIN PROGRAM'S COMMON / CV3 / )
M - VECTOR DIMENSION
                ( LOCAL - MAIN PROGRAM'S DCT )
MAPBND(100) - BOUND COLUMN INDICES
                ( LOCAL - MAIN PROGRAM'S MAPOUT )
MAPBAS(100) - BASIC COLUMN INDICES
                ( LOCAL - MAIN PROGRAM'S MAPOUT )
MAPKEY(1000) - KEY COLUMN INDICES
                ( LOCAL - MAIN PROGRAM'S MAPOUT )
MAPNLL(10) - NULL COLUMN INDICES
                ( LOCAL - MAIN PROGRAM'S MAPOUT )
MAXL - TEMP. STORAGE FOR VEHICLE LIFE
                ( LOCAL - MATRIX GENERATOR'S GENLCP )
MAXTRY - MAXIMUM NUMBER OF IN-CORE ITERATIONS
                (GLOBAL - MAIN PROGRAM'S COMMON / LIMS / )
MC - LAST LOGICAL COLUMN
                (GLOBAL - MAIN PROGRAM'S COMMON / I / )
MCOL - NUMBER OF COLUMNS IN MATRIX
                ( LOCAL - MATRIX GENERATOR'S GENLCP )
MM - NUMBER OF ELEMENTS IN BASIS INVERSE
                ( LOCAL - MAIN PROGRAM'S MAPOUT )
                ( LOCAL - MAIN PROGRAM'S MAPIN )
MNC - THE NEGATIVE OF NCE
                ( LOCAL - MAIN PROGRAM'S PRCAV2 )
```

```
MNTRY - NUMBER OF IN-CORE ITERATIONS
                ( LOCAL - MAIN PROGRAM'S STATUS )
MNX - THE NEGATIVE OF N
                ( LOCAL - MAIN PROGRAM'S BBCAV2 )
MP1 - M PLUS 1
                ( LOCAL - MAIN PROGRAM'S MAPOUT )
MPK - ROW OF COLUMN WHICH WAS KEY
                ( LOCAL - MAIN PROGRAM'S KEYCH )
MPLUS - NUMBER OF ROWS IN THE MATRIX INCLUDING THE COST ROW (M+1)
                (GLOBAL - MAIN PROGRAM'S COMMON / CV3 / )
MPL - M PLUS L
                (GLOBAL - MAIN PROGRAM'S COMMON / I / )
MROWS - USER'S NUMBER OF ROWS
                ( LOCAL - MAIN PROGRAM'S LP )
N - NUMBER OF COLUMNS IN MATRIX
                (GLOBAL - MAIN PROGRAM'S COMMON / CV3 / )
N - NUMBER OF COLUMNS CURRENTLY SAVED
                ( LOCAL - MAIN PROGRAM'S INSERT )
NAAM - NOT USED
                ( LOCAL - MAIN PROGRAM'S IO )
NAMEN (10) - POINTERS FOR NUMBERING RESOURCES
                (GLOBAL - MATRIX GENERATOR'S COMMON / VECSTG / )
NAMEN(10) - NOT USED
                (GLOBAL - REPORT GENERATOR'S COMMON / VECSTG / )
NAMES(5) - COLUMN INDICES FROM MAP CARD
                ( LOCAL - MAIN PROGRAM'S MAPIN )
NAMES (10) - TEMPORARY POINTERS
                ( LOCAL - MATRIX GENERATOR'S GENLCP )
NAME(600) - STATE OF EACH VARIABLE OR COLUMN
                (GLOBAL - MAIN PROGRAM'S COMMON / NAMES / )
NAME - COLUMN NAME, OR POSITION IN CORE TO WHICH COLUMN IS READ
                ( LOCAL - MAIN PROGRAM'S IO )
NB - NUMBER OF BASIC VARIABLES IN A PACKET
                ( LOCAL - MAIN PROGRAM'S FEASCH )
NBCH - NUMBER OF COLUMNS IN BATCH
                ( LOCAL - MAIN PROGRAM'S CHECK )
NBDS - NUMBER OF BOUNDS
                (GLOBAL - MAIN PROGRAM'S COMMON / BOUNDS / )
NBVPKT - NUMBER OF BASIS VARIABLE IN SELECTED GUB ROW
                ( LOCAL - MAIN PROGRAM'S PRIMAL )
NC - NUMBER OF BASIS CARDS TO BE READ FROM INPUT
                ( LOCAL - MAIN PROGRAM'S READIN )
NCF - NUMBER OF NON-LINEAR VARIABLES
                (GLOBAL - MAIN PROGRAM'S COMMON / CV3 / )
NCF1 - NCF
                ( LOCAL - MAIN PROGRAM'S BBCAV2 )
NCF4 - NORA + 3 * NCF
                ( LOCAL - MAIN PROGRAM'S BBCAV2 )
NCHGS - USER'S NUMBER OF BOUND COLUMNS
                ( LOCAL - MAIN PROGRAM'S LP )
NCOLS - NUMBER OF COLUMNS READ FROM DISC FILE IA1
                ( LOCAL - MAIN PROGRAM'S STATUS )
```

```
NCOLS - USER'S NUMBER OF COLUMNS
                ( LOCAL - MAIN PROGRAM'S LP )
NCORE - NUMBER OF COLUMNS IN CORE
                ( LOCAL - MAIN PROGRAM'S COLUMN )
NCRMAX - MAXIMUM NUMBER OF COLUMNS WHICH FIT IN CORE
                (GLOBAL - MAIN PROGRAM'S COMMON / LIMS / )
NDEGLM - MAXIMUM REJECTION DUE TO DEGENERACY
                ( LOCAL - MAIN PROGRAM'S PRIMAL )
NDEG - NUMBER OF DEGENERACY REJECTIONS
                ( LOCAL - MAIN PROGRAM'S PRIMAL )
NDJS - NUMBER OF NEGATIVE DJ'S
                (GLOBAL - MAIN PROGRAM'S COMMON / STATE / )
NDJST - NUMBER OF NEGATIVE DJ'S FROM DISK READ
                ( LOCAL - MAIN PROGRAM'S COLUMN )
NDX(10) - INDICES OF NON-LINEAR VARIABLES
                ( LOCAL - MAIN PROGRAM'S NXBRN )
NEM1 - NUMBER OF ELEMENTS IN AN ARRAY MINUS ONE
                ( LOCAL - MAIN PROGRAM'S GETASO )
NEWXZ - FLAGS WHEN NEW BEST SOLUTION FOUND AND SHOULD BE OUTPUT
                (GLOBAL - MAIN PROGRAM'S COMMON / CV7 / )
NEWROW - ROW FOR COLUMN CHANGING FROM KEY TO BASIC
                ( LOCAL - MAIN PROGRAM'S PRIMAL )
NF1 - SIGNIFIES FEASIBLE SOLUTION WHEN SET EQUAL TO 1
                (GLOBAL - MAIN PROGRAM'S COMMON / CV7 / )
NFRCH - NUMBER OF COLUMNS RETAINED FROM BATCH
                ( LOCAL - MAIN PROGRAM'S CHECK )
NFREE - NUMBER OF GAPS (EMPTY LOCATION BETWEEN TWO FILLED LOCATIONS) IN
THE BLIST
                ( LOCAL - MAIN PROGRAM'S PRCAV2 )
NFX - THE NEGATIVE OF NCF
                ( LOCAL - MAIN PROGRAM'S NXBRN )
NINHP - NUMBER OF INHERITED PERIODS
                ( LOCAL - MATRIX GENERATOR'S GENLCP )
NIV - NUMBER OF INHERITED VEHICLE TYPES
                ( LOCAL - MATRIX GENERATOR'S GENLCP )
NJOUT - NAME CODE OF COLUMN TO BE REJECTED
                ( LOCAL - MAIN PROGRAM'S STATUS )
NL (10) - TEMP. STORAGE USED IN FORMATTING OUTPUT
                ( LOCAL - MATRIX GENERATOR'S GENLCP )
NMIN - INDEX OF THE LOWEST BOUND ON THE BLIST, OR N-1, DEPENDING ON WHERE
IT IS USED
                ( LOCAL - MAIN PROGRAM'S PRCAV2 )
NN (10) TEMP. STORAGE USED IN FORMATTING OUTPUT
                ( LOCAL - MATRIX GENERATOR'S GENLCP )
NOBOL - NUMBER OF NODES ON LIST
                (GLOBAL - MAIN PROGRAM'S COMMON / CV8 / )
NOL - INDEX FOR STORAGE ON BLIST
                ( LOCAL - MAIN PROGRAM'S PRCAV2 )
NOP - NODE NUMBER
                (GLOBAL - MAIN PROGRAM'S COMMON / CV7 / )
NOPS - NODES SOLVED
                (GLOBAL - MAIN PROGRAM'S COMMON / CV7 / )
```

```
NORA - NUMBER OF ROWS IN THE MATRIX INCLUDING THE OBJECTIVE FUNCTION
                ( LOCAL - MAIN PROGRAM'S PRCAV2 )
                ( LOCAL - MAIN PROGRAM'S PRESET )
NOTE(4) - 40 CHARACTER COMMENT
                ( LOCAL - MAIN PROGRAM'S STATUS )
NP - NUMBER OF SUBPERIODS
                (GLOBAL - REPORT GENERATOR'S COMMON / PARAMS / )
NPRCH   NUMBER OF COLUMNS TO BE SAVED FROM BATCH
                ( LOCAL - MAIN PROGRAM'S INSERT )
NPERYR (10, 3) - FIRST AND LAST YEAR OF PERIOD AND NUMBER OF TASKS IN PERIOD
                (GLOBAL - MATRIX GENERATOR'S COMMON / PRDSIG / )
NPHASE - STORES LP PHASE CODE
                (GLOBAL - MAIN PROGRAM'S COMMON / CM / / )
NPIF - NUMBER OF PRIMAL INFEASIBILITIES
                (GLOBAL - MAIN PROGRAM'S COMMON / STATE / )
NPP - NUMBER OF PERIODS
                ( LOCAL - MATRIX GENERATOR'S GENLCP )
NPTASK (10, 9) - ID NUMBER OF EACH TASK IN PERIOD
                (GLOBAL - MATRIX GENERATOR'S COMMON / PRDSIG / )
NPT - NUMBER OF PERIOD TABLES READ
                ( LOCAL - MATRIX GENERATOR'S GENLCP )
                ( LOCAL - REPORT GENERATOR'S SETUP )
NRD - NUMBER OF VEHICLES HAVING R AND D
                ( LOCAL - MATRIX GENERATOR'S GENLCP )
NREJ - NUMBER OF REJECTED IN-CORE COLUMNS
                (GLOBAL - MAIN PROGRAM'S COMMON / STATE / )
NROW - NUMBER OF ROWS IN MATRIX
                ( LOCAL - MATRIX GENERATOR'S GENLCP )
NV - NUMBER OF RESOURCE TYPES
                (GLOBAL - REPORT GENERATOR'S COMMON / PARAMS / )
NSCAN - NUMBER OF DISC READS
                (GLOBAL - MAIN PROGRAM'S COMMON / LIMS / )
NT - NUMBER OF TASKS
                ( LOCAL - MATRIX GENERATOR'S GENLCP )
NT - TOTAL NUMBER OF COLUMNS (MC+INPUTN)
                (GLOBAL - MAIN PROGRAM'S COMMON / I / )
NT - NUMBER OF TASKS (NOT USED)
                ( LOCAL - REPORT GENERATOR'S SETUP )
NTR - NUMBER OF TASK TABLES READ
                ( LOCAL - MATRIX GENERATOR'S GENLCP )
NTRY - NUMBER OF IN-CORE ITERATIONS
                (GLOBAL - MAIN PROGRAM'S COMMON / LIMS / )
NTSK (9) - NUMBER OF ALTERNATIVES IN TASK
                (GLOBAL - MATRIX GENERATOR'S COMMON / TSKSIG / )
NULL - 'NULL'
                ( LOCAL - MAIN PROGRAM'S MAPIN )
NULL - COLUMN STATE
                ( LOCAL - MAIN PROGRAM'S COLUMN )
NV - NUMBER OF VEHICLE TYPES
                ( LOCAL - MATRIX GENERATOR'S GENLCP )
NVEHU (10) - INDICATES IF VEHICLE USED IN PERIOD
                ( LOCAL - MATRIX GENERATOR'S GENLCP )
```

```
NVR - NUMBER OF VEHICLE TABLES READ
                ( LOCAL - MATRIX GENERATOR'S GENLOD )
                ( LOCAL - REPORT GENERATOR'S SETUP )
NWAJ - STORAGE DIMENSION OF THE ARRAY AJ
                ( LOCAL - MAIN PROGRAM'S LD )
NXBX - INDEX OF BRANCHING VARIABLE
                (GLOBAL - MAIN PROGRAM'S COMMON / CVR / )
NXBL(25) - INDEX OF BRANCHING VARIABLE FOR EACH NODE
                (GLOBAL - MAIN PROGRAM'S COMMON / CVR / )
NXB - TEMPORARY STORAGE FOR NEXT BRANCHING VARIABLE
                ( LOCAL - MAIN PROGRAM'S BRCAV2 )
NYR - TEMP. STORAGE FOR LAST YEAR OF PERIOD
                ( LOCAL - MATRIX GENERATOR'S GENLOD )
OANDM(20) - OPERATING COST FOR EACH YEAR
                (GLOBAL - REPORT GENERATOR'S COMMON / OCTS / )
ONE - '01'
                ( LOCAL - REPORT GENERATOR'S CINFO )
ONE - 1.0
                ( LOCAL - MATRIX GENERATOR'S GENLOD )
ONEM - -1.0
                ( LOCAL - MATRIX GENERATOR'S GENLOD )
PACK(100) - TEMPORARY STORAGE OF PACKED COLUMN
                ( LOCAL - MAIN PROGRAM'S IO )
PER(10) - POINTERS FOR TWO DIGIT, ALPHANUMERIC CODE FOR PERIODS
                (GLOBAL - REPORT GENERATOR'S COMMON / BASICS / )
PERIOD - 'PERIOD'
                ( LOCAL - REPORT GENERATOR'S CINFO )
                ( LOCAL - REPORT GENERATOR'S PINFO )
PH1 AND PH2 - TEMPORARY STORAGE OF VALUES FROM GETPHI
                ( LOCAL - MAIN PROGRAM'S BRCAV2 )
PHIT - COST OF A NON-LINEAR SOLUTION
                (GLOBAL - MAIN PROGRAM'S COMMON / CV3 / )
PIKEY - DJ VALUE FOR CURRENT KEY JPKT
                ( LOCAL - MAIN PROGRAM'S COLUMN )
PIKEY - DJ FOR CURRENT KEY AT KORG
                ( LOCAL - MAIN PROGRAM'S CHECK )
PIVTOL - PIVOT TOLERANCE
                (GLOBAL - MAIN PROGRAM'S COMMON / TOLS / )
PIV - PIVOT USED
                ( LOCAL - MAIN PROGRAM'S PIVOT )
PKT1 - TEMPORARY COUNT OF SUB ROW PACKET COLUMNS
                ( LOCAL - MAIN PROGRAM'S SETUP )
PKT - ACTUAL SUB ROW COLUMN BEING PROCESSED
                ( LOCAL - MAIN PROGRAM'S SETUP )
PKT - STORAGE OF COLUMN PACKET
                ( LOCAL - MAIN PROGRAM'S MAPIN )
PKT - SUB PACKET NUMBER OF COLUMN BEING PROCESSED
                ( LOCAL - MAIN PROGRAM'S INVERT )
PKT - PACKET OF NEW COLUMN, JNT
                ( LOCAL - MAIN PROGRAM'S CHECK )
PKT - SUB PACKET OF DESIRED KEY
                ( LOCAL - MAIN PROGRAM'S KEYEND )
PKT2 - SUB PACKET NUMBER OF COLUMN IN AJ(KORG)
PKTO - PACKET OF CURRENT KEY
                ( LOCAL - MAIN PROGRAM'S CHECK )
                ( LOCAL - MAIN PROGRAM'S INVERT )
```

```
PMIN - VALUE OF LOWEST BOUND ON BLIST
                ( LOCAL - MAIN PROGRAM'S BRCAV2 )
PERTOL - PRIMAL ERROR TOLERANCE
                (GLOBAL - MAIN PROGRAM'S COMMON / TOLS / )
PRMLER - PRIMAL ERROR, UNUSED
                (GLOBAL - MAIN PROGRAM'S COMMON / MOVES / )
PROC(20) - PROCUREMENT FUNDS SPENT DURING EACH PERIOD
                (GLOBAL - REPORT GENERATOR'S COMMON / OUTS / )
PROT(20) - PROCUREMENT FUNDS AVAILABLE DURING EACH PERIOD
                (GLOBAL - REPORT GENERATOR'S COMMON / OUTS / )
PSIGL(25) - LOWER BOUND ASSOCIATED WITH EACH NODE ON LIST
                (GLOBAL - MAIN PROGRAM'S COMMON / CV9 / )
PTASK (10, 9) - MULTIPLICATIVE FACTOR FOR ALL VALUES IN ASSOCIATED TASK FOR
EACH PERIOD
                (GLOBAL - MATRIX GENERATOR'S COMMON / PROJTG / )
PURCH(10,20) - NUMBER OF EACH TYPE RESOURCE PURCHASED IN EACH YEAR
                (GLOBAL - REPORT GENERATOR'S COMMON / OUTS / )
R - RATE OF INCREASE IN OPERATING COST
                ( LOCAL - MATRIX GENERATOR'S YRCOST )
R - 'RHS'
                ( LOCAL - MATRIX GENERATOR'S MATFILL)
R1 - PORTION OF OPERATING COST REFUNDED FOR MOTH BALLING RESOURCE
                ( LOCAL - MATRIX GENERATOR'S YRCOST )
RDTOT - TOTAL R AND D EXPENDITURES
                (GLOBAL - REPORT GENERATOR'S COMMON / PARAMS / )
RHS(100) - STORES USER'S CURRENT RIGHT HAND SIDE
                (GLOBAL - MAIN PROGRAM'S COMMON / RHS / )
RNAME(120) - ROW NAMES
                ( LOCAL - MATRIX GENERATOR'S MATFILL)
ROWS - 'ROWS'
                ( LOCAL - MAIN PROGRAM'S MAPIN )
RP(12) - STORAGE FOR REAL PARAMETERS, FIRST FOUR LOCATIONS ARE FOR INPUT
FROM REAL PARAMETER CARD, REST ARE TEMPORARY STORAGE
                (GLOBAL - MAIN PROGRAM'S COMMON / CV1 / )
RTEMP - TEMP. STORAGE FOR ROW NAMES
                ( LOCAL - MATRIX GENERATOR'S MATFILL)
RVAL(100) - VECTOR OF VALUES IN EACH ROW FOR A SPECIFIC COLUMN
                ( LOCAL - MATRIX GENERATOR'S MATFILL)
S - 'S'
                ( LOCAL - REPORT GENERATOR'S INSOLN )
SALE(20) - SALVAGE OR TRUNCATION VALUE FOR EACH YEAR
                (GLOBAL - REPORT GENERATOR'S COMMON / OUTS / )
SALV(10,20) - NUMBER OF EACH TYPE RESOURCE DISPOSED OF AT END OF EACH YEAR
                (GLOBAL - REPORT GENERATOR'S COMMON / OUTS / )
SAVE(20) - SAVINGS FROM RESOURCE STORAGE FOR EACH YEAR
                (GLOBAL - REPORT GENERATOR'S COMMON / OUTS / )
SECS - ACTUAL CPU CLOCK TIME
                ( LOCAL - MAIN PROGRAM'S TIMEC )
SIGMA(100,4) - STORES INFORMATION WHICH DEFINES THE CURRENT NODE
                (GLOBAL - MAIN PROGRAM'S COMMON / CV5 / )
STEP - STEP TO CURRENT ROW
                ( LOCAL - MAIN PROGRAM'S ROW )
STOR(10,20) - NUMBER OF EACH TYPE RESOURCE STORED IN EACH YEAR
                (GLOBAL - REPORT GENERATOR'S COMMON / OUTS / )
```

```
SUM - VALUE OF VARIABLE BEFORE FEASIBILITY ADJUSTMENT
                ( LOCAL - MAIN PROGRAM'S FEASCH )
SUM - TEMPORARY STORAGE
                ( LOCAL - MAIN PROGRAM'S KEYCH )
SUM - DOUBLE PRESISION ACCUMULATOR
                ( LOCAL - MAIN PROGRAM'S OOI )
SUM - TOTAL COST FOR A PERIOD
                ( LOCAL - REPORT GENERATOR'S CINFO )
SUMIE - SUM OF INFEASIBILITIES
                ( LOCAL - MAIN PROGRAM'S FEASCH )
SUMT - TOTAL COST FOR ALL PERIODS
                ( LOCAL - REPORT GENERATOR'S CINFO )
SY - START YEAR OF PROBLEM
                ( LOCAL - MATRIX GENERATOR'S GENLOP )
T(100,10) - STORAGE FOR COLUMNS OF MATRIX ASSOCIATED WITH NON-LINEAR
VARIABLES
                (GLOBAL - MAIN PROGRAM'S COMMON / CV2 / )
TCOST - TEMP STORAGE FOR TOTAL PROCUREMENT
                ( LOCAL - REPORT GENERATOR'S CINFO )
TEMP - LOCATION USED WHILE SWAPPING CONTENTS OF TWO LOCATIONS IN AN ARRAY
                ( LOCAL - MAIN PROGRAM'S GETASO )
TEMP1 - TEMPORARY STORAGE LOCATIONS FOR ALPHANUMERIC OUTPUT
                ( LOCAL - REPORT GENERATOR'S PINFO )
TEMP2 - TEMPORARY STORAGE LOCATIONS FOR ALPHANUMERIC OUTPUT
                ( LOCAL - REPORT GENERATOR'S PINFO )
TEMP(4) - TEMP STORAGE FOR COLUMN NAMES
                ( LOCAL - REPORT GENERATOR'S SETUP )
THETA - STEP CHOSEN BY ROW, ADJUSTED IN PRIMAL
                (GLOBAL - MAIN PROGRAM'S COMMON / MOVES / )
THETA - BEST FEASIBLE STEP
                ( LOCAL - MAIN PROGRAM'S ROW )
TITLE(4) - ALPHANUMERIC TITLE OF PROBLEM
                ( LOCAL - MAIN PROGRAM'S PRCAV2 )
                (GLOBAL - REPORT GENERATOR'S COMMON / PARAMS / )
TMAX - MAXIMUM TIME BEFORE TIMEOUT
                (GLOBAL - MAIN PROGRAM'S COMMON / PARAMS / )
TMO - TIME SET WAS CALLED
                (GLOBAL - MAIN PROGRAM'S COMMON / TMX / )
TMP(10) - TEMPORARY STORAGE
                (GLOBAL - MAIN PROGRAM'S COMMON / CV1 / )
TOT - NUMBER OF SUBPERIODS PLUS 1
                (GLOBAL - REPORT GENERATOR'S COMMON / PARAMS / )
TOTAL - 'TOTAL'
                ( LOCAL - REPORT GENERATOR'S CINFO )
                ( LOCAL - REPORT GENERATOR'S PINFO )
TPROC - CORRECTION FACTOR FOR PROCUREMENT
                ( LOCAL - REPORT GENERATOR'S CINFO )
TSIG - TEMPORARY STORAGE ASSOCIATED WITH EKO
                (GLOBAL - MAIN PROGRAM'S COMMON / CVE / )
TSTR(130) - TEMPORARY STORAGE
                ( LOCAL - MAIN PROGRAM'S PRCAV2 )
TYPE1 - FIRST WORD ON MAP CARD
                ( LOCAL - MAIN PROGRAM'S MAPIN )
```

```
TYPE2 - SECOND WORD ON MAP CARD
                ( LOCAL - MAIN PROGRAM'S MAPIN )
U (7, 288, 9) - ARRAY OF TASK ALTERNATIVES
                (GLOBAL - MATRIX GENERATOR'S COMMON / TSKSTG / )
UB (10) - CALCULATED UPPER BOUNDS ON RESOURCES
                ( LOCAL - MATRIX GENERATOR'S GENLCP )
UBK - UPPER BOUND ON BRANCHING VARIABLE
                ( LOCAL - MAIN PROGRAM'S BRCAV2 )
UBK2 - DIFFERENCE BETWEEN UPPER BOUND AND VALUE FOR BRANCHING VARIABLE
                ( LOCAL - MAIN PROGRAM'S BRCAV2 )
ULO(10) - SET OF UPPER BOUNDS ON NON-LINEAR VARIABLES
                (GLOBAL - MAIN PROGRAM'S COMMON / CV2 / )
ULT(10) - TEMPORARY STORAGE FOR ULO
                ( LOCAL - MAIN PROGRAM'S BRCAV2 )
UMAX - TEMP. STORAGE FOR GREATEST QUANTITY OF A SPECIFIC VEHICLE WHICH MIGHT
BE USED IN A TASK
                ( LOCAL - MATRIX GENERATOR'S GENLCP )
US - TEMPORARY STORAGE FOR USP
                ( LOCAL - MAIN PROGRAM'S BRCAV2 )
USM = UZ/(1-E)
                (GLOBAL - MAIN PROGRAM'S COMMON / CV3 / )
USP = UZ/(1+E)
                (GLOBAL - MAIN PROGRAM'S COMMON / CV3 / )
UZ - COST OF BEST NON-LINEAR SOLUTION
                (GLOBAL - MAIN PROGRAM'S COMMON / CV3 / )
VAL - COLUMN VALUE TEMPORARY STORAGE
                ( LOCAL - REPORT GENERATOR'S INSOLN )
VAL - TEMP. STORAGE FOR VALUE OF SPECIFIC ROW AND COLUMN
                ( LOCAL - MATRIX GENERATOR'S MAIFILL)
VCOST(10,5) - THE FIVE COSTS ASSOCIATED WITH EACH RESOURCE ARE STORED IN
THIS ARRAY - IN ORDER, THEY ARE SALVAGE AND TRUNCATION, OPERATING, R AND D,
RETENTION RATE, AND PROCUREMENT.
                (GLOBAL - MATRIX GENERATOR'S COMMON / VECSTG / )
                (GLOBAL - REPORT GENERATOR'S COMMON / VECSTG / )
VLIFE (10) - MAXIMUM LIFE OF RESOURCE (VEHICLE)
                (GLOBAL - MATRIX GENERATOR'S COMMON / VECSTG / )
                (GLOBAL - REPORT GENERATOR'S COMMON / VECSTG / )
VMIN  - TEMP. STORAGE FOR MINIMUM QUANTITY OF VEHICLES WHICH CAN BE USED FOR
TASK
                ( LOCAL - MATRIX GENERATOR'S YINTERP )
VNAME(10) - STORES RESOURCE NAMES
                (GLOBAL - MATRIX GENERATOR'S COMMON / VECSTG / )
                (GLOBAL - REPORT GENERATOR'S COMMON / VECSTG / )
W - 'W'
                ( LOCAL - REPORT GENERATOR'S INSOLN )
X - INPUT VECTOR
                ( LOCAL - MAIN PROGRAM'S DOT )
X - 'X'
                ( LOCAL - REPORT GENERATOR'S INSOLN )
X - ELAPSED CPU SECONDS
                ( LOCAL - MAIN PROGRAM'S STATUS )
XCON(10) - STORES VALUES FOUND IN X WHICH ARE ASSOCIATED WITH THE
NON-LINEAR VARIABLES
                (GLOBAL - MAIN PROGRAM'S COMMON / CV4 / )
```

```
XK - VALUE OF BRANCHING VARIABLE
                (GLOBAL - MAIN PROGRAM'S COMMON / CV8 / )
XNXBL(25) - VALUE OF BRANCHING VARIABLE FOR EACH NODE
                (GLOBAL - MAIN PROGRAM'S COMMON / CV9 / )
XT(10) - SOLUTION VALUES FOR NON-LINEAR VARIABLE
                ( LOCAL - MAIN PROGRAM'S NXBRN )
XX- ELAPSED TIME ON PROBLEM
                ( LOCAL - MAIN PROGRAM'S TIMEC )
X(100) - VALUES OF SOLUTION COLUMNS
                (GLOBAL - MAIN PROGRAM'S COMMON / AA / )
X(110) - VALUES ASSOCIATED WITH COLUMNS IN IX
                (GLOBAL - MAIN PROGRAM'S COMMON / CV4 / )
XZ(110) - VALUES ASSOCIATED WITH COLUMNS IN IXZ
                (GLOBAL - MAIN PROGRAM'S COMMON / CV4 / )
Y - INPUT VECTOR
                ( LOCAL - MAIN PROGRAM'S DOT )
YAVL (10) - YEAR RESOURCE FIRST AVAILABLE
                (GLOBAL - MATRIX GENERATOR'S COMMON / ALTSTG / )
YEARS (21) - STORES INHERITED YEARS
                ( LOCAL - MATRIX GENERATOR'S GENLCP )
YRINT (20) - SCALE FACTOR FOR ALL TASKS IN PERIOD
                ( LOCAL - MATRIX GENERATOR'S GENLCP )
YT(10) - DIFFERENCES BETWEEN SOLUTION POINT AND LOWER BOUNDS
                ( LOCAL - MAIN PROGRAM'S NXBRN )
Z - PARAMETER USED TO PACK INDEX OF COEFFICIENT
                ( LOCAL - MAIN PROGRAM'S IO )
G9H8 8 7==!977 H9!879IG9= 97=!9H
                (GLOBAL - MAIN PROGRAM'S COMMON / TOLS / )
ZS - PARAMETER USED TO PACK COEFFICIENTS
                ( LOCAL - MAIN PROGRAM'S IO )
```

REFERENCES FOR VOLUME I

1. J. C. Hetrick, "Mathematical Models in Capital Budgeting," Chapter 7. New Decision Making Tools for Managers; edited by E. C. Bursk and J. F. Chapman, (Cambridge, Harvard University Press, 1963) p. 186.

2. J. E. Falk and R. M. Soland, "An Algorithm for Separable Non-Convex Programming Problems," Management Science, Vol. 15, No. 9, May 1969.

3. E. M. L., Beale, "Advanced Algorithmic Features for General Mathematical Programming Systems," Integer and Nonlinear Programming, edited by J. Abadie, North-Holand Publishing Company, 1970.

REFERENCES FOR VOLUME II

4. R. New, "Optimal Planning Over Time — OPT," Journal of Systems Management, March 1972.

5. R. M. Soland, "An Algorithm For Separable Non-Convex Programming Problems II: Non-Convex Constraints," Management Science, Volume 17, No. 11, July 1971.